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An empirical comparison of theoretical and actual decision making under uncertainty

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AN EMPIRICAL COMPARISON OF THEORETICAL AND ACTUAL DECISION MAKING UNDER UNCERTAINTY

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I. INTRODUCTION

No economic decisions of practical import are made under conditions in which the relevant future is known with certainty. Invariably, elements of uncertainty are present. In consequence, an *ex ante* algorithm for efficient allocation of the entrepreneur's resources on an *ex post* basis is impossible. *Ex ante* he may make his decisions to accommodate the influence of uncertainty, but *ex post* he will, except for chance occurrences, be able to see that a more profitable allocation of resources would have been possible. Reduction of this misallocation is the normative economic problem (42, p. 49) in decision making under uncertainty. Concomitant is a problem of positive or descriptive economics (25, p. 8). To wit, how are decisions made? Why was this pattern of resource use chosen and not another?

Recognition of these problems has led to the elaboration in recent years of a number of theories of choice in risk-taking situations. As is later shown, these theories are not disjunct.

Most numerous are theories stressing a rather mechanical application of simple mathematical rules of thumb to the decision problem. Included in this group are those procedures usually referred to as naive models of decision making (30, p. 478). However, these are subsumed under the more general theories of decision making stemming from von Neumann and

Morgenstern's (57, p. 617) axiomatic treatment of choice among probability distributions and from Wald's (86) contributions to statistical inference. These algorithms are mathematically well-defined and attempt to maximize the decision maker's utility function. They stress rational behavior and are therefore normative. Also, they have not been promulgated as general theories for all decision makers in all choice situations. Opposing such theories, at least to a degree, is Shackle's (69, 72, 73) formulation emphasizing a psychological approach based on the individual's degrees of belief and potential surprise relevant to a given decision problem. This theory is essentially positive. It has been hypothesized by Shackle as the general mode of decision making in non-divisible non-seriable choice situations (73, p. 5). That is, for choice situations that are unique in the sense that no actuarial frequency ratios applicable to the possible outcomes are available. Lying between the above theories in its emphasis on mathematical procedures and psychological variables is Simon's (75, pp. 241-260) theory. In this theory, the decision maker is portrayed as merely trying to satisfy some level of aspiration - he is a satisficer rather than a maximizer.

A masterly appraisal, albeit theoretical, of all these theories has been given by Arrow (4, 6). Edwards (20) has made an expository survey of the relevant literature.

To date none of these theories have been assessed in terms of their real-world roles, either normative or descriptive. In part this is a reflection of the fact that they are theories and, being such, relate to idealizations of the real world whose mapping into complex practical situations is difficult. This study is an attempt to make such an assessment for some of these theories; specifically, for those theories that relate to choice under absolute uncertainty. In such circumstances the decision maker has no objective knowledge of the likelihood of occurrence of the various possible outcomes of his decision. He knows only what outcomes may occur. The relevant theories are those of Simon and Shackle together with, of a more mathematical nature, Laplace's principle of insufficient reason as elaborated by Luce and Raiffa (48), Wald's (86) maximin criterion, Hurwicz's (36) pessimism-optimism index approach, Savage's (67) minimax regret procedure and also the latter's subjective probability approach (66).

The empirical setting analyzed is the decision problem facing a Mid-West farmer in choosing among alternatives within his feeder cattle enterprise in a given year. That the decision makers are farmers and that the problem relates to feeder cattle is of relatively little consequence. It is an accident. Qualitatively, the important fact for this study is that, in the given setting, plans normally have to be made and decisions taken under conditions of absolute uncertainty. However, any quantitative implications of the analysis can only be interpreted in terms of the actual setting of the decision problem.

Part I of the dissertation presents a rational structuring of the resource allocation problem facing entrepreneurs operating under conditions of free competition. It is shown that in such situations the decision problem can and should be posed in a simpler way than as an n-person non-zero sum game (57). An exposition of the theories of decision making relevant to this model is also given. Part II is empirical. It begins with a description of the source of the data and its collection. An appraisal of the model is then given, followed by an assessment of the normative and descriptive rôles of the various theories of choice.

PART I. THEORETICAL

II. THEORETICAL MODEL

In this chapter we explore the logic of the general decision making situation that will be studied later in a particular empirical context.

Role of the Model

Our aim is to develop an analytic framework. Within this framework, we will later examine our empirical data in the light of the theories of decision making under uncertainty that we wish to assess.

This analytic framework happens to be a normative mathematical model. To be of practical use, such a model must be capable of empirical application. If it is, it may also be true as a descriptive model. Accordingly, the model will be appraised in Part II in terms of its agreement with the conception of the decision making environment held by the actual group of entrepreneurs studied. In making this appraisal we will not, as Papandreou (61, p. 138) has stressed, be able to reject the model, but only to confirm or not confirm it for the historical individuals studied.

The model constructed consists of a set of assertions constituting a mathematical abstraction of the real world situation. To any such model, in any branch of science, mathematical arguments yielding mathematical conclusions can be applied. This can be done because such a model constitutes a mathematical system (88, p. 13). These mathematical conclusions can, in turn, be interpreted back into real-world conclusions. In most fields of science, an alternative path from the real-world problem to real-world conclusions is possible. Thus in the physical sciences, experimentation is often feasible and serves as a check on the theoretical abstraction and interpretation. In economics, observation and introspection must, in general, take the place of experimentation (42, p. 143). But there is a difference: in economics we may have both normative and positive theories. For a normative model, observation and introspection do not necessarily serve as a check. If the normative model happens to be a true descriptive model, then both paths will agree. Otherwise they will not. However, in so far as man does behave as the profit maximizing *homo oeconomicus* that economics postulates (65, p. 96), some degree of agreement between the results derived from a normative model and the conclusions from observation and introspection must be expected. Whether or not the supposedly normative conclusions drawn from a postulated normative model are truly normative depends only on the correctness of the mathematical assumptions, arguments and interpretations made. The writer contends that the model and interpretation which follow do satisfy these requirements. Hence we propose that the model is a satisfactory vehicle for assessing both the normative and descriptive roles of the theories to be examined.

We now construct the model, first describing the real-world situation; then proceeding to the correct model via a game theoretic analysis of the relevant environment.

The Decision Problem

We are concerned with groups[1] of entrepreneurs, the totality of groups constituting a chain in the sense that each lower group in the hierarchy produces a commodity that is, generically, the major input for the next highest group in the chain. The entrepreneurs in each group have some number of alternative ways in which they can transform this input. If it were assumed that no economic or other restrictions existed, then for every member of each group there would be a common set of alternatives or transformation processes. However, restrictions do exist. Hence the set of alternatives facing a given decision maker may or may not be, in part or in full, the same as the set facing another decision maker in the same group.

These alternatives will vary in profitability. Firstly, the greater the extent to which a particular alternative is selected by entrepreneurs within a particular group, the less

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[1]The word group is used throughout in its normal dictionary sense of a cluster and not in its mathematical sense.

profitable it will be. This is because of the induced higher level of supply of the output specific to that alternative. This specific output, of course, belongs to the generic output common to the whole group. Secondly, the profitability will vary with the particular concatenation of policies followed by the groups above and below in the hierarchy. Those groups below, through their decisions, determine input supplies. Those higher in the hierarchy determine the level of demand for the output from a particular transformation process. These inter and intra group influences are endogenous to the overall system. There may also be exogenous influences on the profitability of a given alternative. For example, climatic conditions may be important.

The economic decision problem facing a member of one of these groups, given the uncertainty that exists in the situation, is to select the production alternative or combination of alternatives that will give him the greatest net revenue in the forthcoming production period. The production period is defined epideiktically as whatever the entrepreneur considers the relevant production period to be. It is assumed that production periods further in the future are ignored; except in so far as they are accounted for by the mode of decision making, conservative or otherwise, that is adopted.

We wish to formulate a model of this situation, being concerned in particular with the decision problem faced by a member of a group that is very large.

Preliminary Considerations

In abstracting this decision problem we will be concerned primarily with a single group of entrepreneurs and their relation to the groups above and below in the hierarchy. Thus we have a totality of entrepreneurs constituting a set N. N is the union of three disjunct non-empty finite sets which we specify as:

- N': the group of entrepreneurs whose decision problem interests us;
- N'': the set of entrepreneurs belonging to all groups above N' in the hierarchy;
- N''': the set of entrepreneurs belonging to all groups below N' in the hierarchy.

Thus we have

$$N = N' \cup N'' \cup N''' \tag{1}$$

where N must contain at least three elements[1].

We may further specify that an entrepreneur $n \varepsilon N$ has some number of alternatives available to him. This number will, in general, vary over the elements of N.

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[1]We could consider the complement, $\tilde{N}$, of N' in N as a single set. We do not because the above presentation is more convenient in terms of the empirical situation to be studied in Part II.

The simplest way in which the decision problem might occur for an $n' \varepsilon N'$ would be if he had only a single alternative. In fact, the decision problem would then be nonexistent.

Now consider the situation if n' has more than one alternative and N contains only three elements. This would correspond to the decision problem facing a monopolist whose input is bought from a monopolist and whose product is sold to a monopsonist. Our chain in this case consists of two bilateral monopoly situations, the net profit accruing to n' being the difference between his costs and revenue. Revenue comes from sales to $n'' \varepsilon N''$ and costs are primarily determined by purchases from $n''' \varepsilon N'''$. However, n" and n"' each have alternatives and the costs and revenues of n' will vary in terms of the alternatives selected by n" and n"'. Indeed, the availability of some of the alternatives of n' may be dependent upon the selection of certain alternatives by n"'.

The situation facing n' might be depicted by a payoff matrix showing the net revenue to n' from each of his alternatives for all combinations of alternatives that might be selected by n" and n"'. The elements of this matrix would not be single valued. Each would represent a range of values. This is necessitated by the fact that we are dealing with bilateral monopoly situations; the entrepreneurs having the power to negotiate and bargain about prices. Suppose that n' selects his i th alternative, n" his j th alternative and n"' his k th alternative. Then the payoff to n' will lie in the range denoted by the payoff element a_{ijk} of his payoff matrix. Payoff matrices could likewise be developed for n" and n"'.

Assuming profit maximization and complete information among n', n" and n"', we have depicted a game involving three players. Moreover it is a non-zero-sum game because the situation is not strictly competitive. All three entrepreneurs may gain in playing the game. What does game theory say of such a situation? von Neumann and Morgenstern (57, p. 556) examined a single bilateral monopoly situation in terms of game theory. They found that a solution, indeterminate within a specified range, was possible. As they point out, common sense gives the same solution. However, the situation with three players is more complicated, for there are now additional bargaining and coalition opportunities available to the players. None the less, von Neumann and Morgenstern were able to formulate all possible solutions for three person non-zero-sum games (57, p. 550). It would be thus possible for n' in the specified situation to choose, by the use of a game theoretic analysis, the alternative(s) which would maximize the value to him of playing the game. He would, of course, have to recognize the conflict and coalition possibilities inherent in the game. Again, the solution would be indeterminate but lie in some specified range.

What happens if the order of N is increased so that, assuming complete information, the situation becomes a game with at least four players? von Neumann and Morgenstern have shown that as the number of players increases, not only does the game theoretic analysis become more complex on account of the number of players involved but also because qualitatively new phenomena appear (57, pp. 339 and 403). Indeed, it is to be expected that the solution to an n-person game will bear no relation to the solution of an (n+1)-person game. For non-zero-sum games with $n>3$ no satisfactory game theory analysis leading to a solution of the decision problem is available (57, p. 542). Thus when the order of N becomes very large, a game theory analysis is useless, even if the assumptions of game theory were satisfied.

Moreover, as the order of N increases, it becomes increasingly difficult to sustain the game theory assumption of complete information. For this assumption to hold true it would be necessary for each player in the game, a number equal to the order of N, to know not only his own payoff matrix but also the payoff matrix of every other player. In addition, the effect of every possible coalition must be evaluated.

Koopmans (45, p. 160), Marschak (51) and Shubik (74, p. 147) have commented upon this problem of obtaining, processing, storing and evaluating information. Shubik shows that if the r th player has α_r alternatives then the total quantity of numbers needed for complete information in an n-person game is $n\prod_{r=1}^{n} \alpha_r$. This quantity increases very rapidly as n increases. Thus if n were 3 and each of the players had five alternatives, 625 numbers would have to be stored. If n were 30 and each had five alternatives, the quantity would be 2,794 followed by 19 zeros. Indeed, the alternatives may not be discrete. They may cover a continuous range, implying what has been termed an infinite game. Such games have been studied by McKinsey (52) and Tucker (81, p. 21) among others. Obviously, the information problem is greatly magnified in situations of this type.

For complete information, the power of all possible coalitions must also be examined. The number of possible coalitions is $\sum_{m=1}^{n} nCm$ or (2^n-1). This quantity, too, increases very rapidly as n rises. Clearly, as the number of players increases, the volume of such information soon becomes much greater than any entrepreneur could store and evaluate. In so far as some of the players might have similar alternatives, the problem would be alleviated a little - if the concomitant information problem of knowing which players had the same alternative had an easy solution. Even if all the above information difficulties could be resolved, the problems of communicating and negotiating possible coalitions remains.

For all these reasons, it is impossible to maintain the assumption of complete information perceived either objectively or subjectively (47). Undoubtedly, this accounts for the fact that there is no correspondence between the economic milieu described as free competition and the expectations of coalition formation one would have of such a group from a game theoretic approach.

Thus a game theoretic model of the decision problem facing an entrepreneur $n' \varepsilon N'$, where the order of N' implies that this set of entrepreneurs is operating under free competition, would be completely unrealistic.

None the less, such an entrepreneur will have at least some information. Certainly he will know something of his own payoff matrix. Now, what might this payoff matrix encompass for a member, n', of a freely competitive group, N'? By definition, if free competition prevails, no entrepreneur in the group has any control over the prices he pays or receives in carrying through a particular production alternative. Hence in developing his payoff matrix he need pay no attention to the individual actions of any of his confreres in the set N'. This feature of the situation was apparently unappreciated by Shubik (74). However, the aggregate actions of a freely competitive group are influential in determining the prices paid and received by individual members of the group. As economic theorists normally explain, the average revenue curve facing an individual in a freely competitive market is a horizontal line while the average revenue curve of the whole group is a negatively sloped line. Therefore such an entrepreneur must estimate his possible payoff for each possible aggregative maneuver of the group to which he belongs. Since his individual influence is zero, he may just as well consider only the aggregate action of all the other members of his group. Of course, the number of such maneuvers will be very large if the number of alternatives available to each member is large.

It must be emphasized that these aggregative actions are not the result of a coalition. Every member of N' makes his decisions independently. These independent decisions taken in toto determine which particular aggregative state of affairs, out of all those possible, does occur.

To what extent must n' take account of the behavior of the members of N" and N"'? If they are also free competitors, only their aggregative actions need be considered, for the reasons already given above. To the extent that they are not freely competitive groups, the actions of individual members of N" and N"' must be considered in constructing the payoff matrix of an $n' \varepsilon N'$.

Even within such a limited picture, an information problem is likely to exist. For instance, suppose an entrepreneur $n' \varepsilon N'$ has 25 alternative ways of processing his major output. Assume further that there are 40 ways in which the aggregated decisions of the remaining members of N' may occur. Now if there are also 40 possibilities relevant to N" and another 40 to N"', the size of the payoff matrix for n' would be 25 by 64,000. Obviously no entrepreneur could construct, let alone evaluate, such a matrix without help. Nor is it unreasonable to say that in most real world problems of the type we are discussing there are many more alternatives available than the number used in this example. How then could an entrepreneur proceed if he had to rely on his own assessment of the decision problem without recourse to assistance? All he could do, assuming he does not wish to choose one of his alternatives at random, is to stratify his own alternatives and those of his opponents taken *en masse*; amalgamating the alternatives within each stratum into a single broad possibility so that his payoff matrix is reduced to a size commensurate with his capabilities. Such a procedure may even be carried further by rejecting some of these broad alternatives, then proceeding to consider only the remainder. Simon (75, p. 244) especially and, to a lesser extent, Bruner *et al* (9, p. 232), Luce (46, p. 208) and Miller (53, *passim*) have hypothesized that such a pattern of simplification is carried out by real world decision makers in complex situations. In fact, such a procedure is the basic feature of Simon's theory of decision making. He has written (75, p. 243):

> Because of the psychological limits of the organism (particularly with respect to computational and predictive ability), actual human rationality-striving can at best be an extremely crude and simplified approximation to the kind of global

rationality that is implied, for example, by game theoretical models.

We shall incorporate such an approximation procedure in our model. In seeking to confirm the model empirically we will therefore be testing this hypothesis of Simon's.

Formulation of the Model

Having explored the above preliminaries, the model may now be presented in succinct form. The elements of the model are:

(1) An entrepreneur $n' \varepsilon N' \subset N$, the order of N' being such that n' operates under free competition.

(2) A point set A of behavior alternatives or acts available to n'.

(3) A partitioning of the set A into subsets A_i. Each A_i is treated as a single broad alternative.

(4) A point set of considered alternatives or acts A° whose elements constitute a subset of the set of subsets, $\{A_i\}$.

(5) A point set S of possible future states of affairs due to the aggregative actions of those entrepreneurs constituting the complement of n' in N and to other factors such as climatic conditions.

(6) A partitioning of S into subsets S_j, each subset S_j being considered as a single possible state of affairs. The subsets S_j will be referred to as

states of Nature.

(7) For each combination of a considered act from the set A° and a state of Nature S_j, a probability distribution of possible payoffs (net revenues) for the forthcoming production period is known. The expected value of the payoff from the i th act and the j th state of Nature is a_{ij}. The set $\left\{a_{ij}\right\}$ is an ordered set.

The aim of n' is to select that act or combination of acts which will maximize his net expected revenue in the forthcoming production period. The selection of a single act A_i° is referred to as a pure strategy; selection of a number of acts is a mixed strategy.

For this model, a course of action is rational if it is compatible with the aim of maximizing expected profit in the forthcoming production period. This definition is extremely narrow. In general, it would be preferable to take account of additional values and motivations that real-world decision makers may have. Schoeffler (68), for instance, has indicated how this might be done ideally.

In his consideration of the decision problem, it is assumed that n' is indifferent between elements of the considered set of acts A°. Only when these acts are adjoined to their respective payoffs is a preference ordering possible. Equivalently, we could assume that any preference ordering among these acts, considered apart from their payoffs, is strongly dominated by the decision maker's desire for profit maximization. Not to make this assumption would lead us into the realm of subjective probabilities (66). To what extent the assumption is a limiting one in an entrepreneurial choice context is a matter that could only be determined by extensive empirical analysis. Moreover, the measurement of subjective probabilities is a problem not entirely solved (13, 45, p. 159).

Also, it is assumed that for n' the utility of a sum of money is directly proportional to its amount and that the utility of a probability distribution of payoffs is directly proportional to the mathematical expectation of the distribution. Hence n' is assumed to evaluate each of his possible acts in terms of the expected payoff values a_{ij}. Some consideration of this assumption is necessary.

If the complex real-world problem is simplified by some process of amalgamating alternatives into a smaller number, it is certainly true that for each of these broader alternatives there is a range of possible payoffs. Even if such a simplifying procedure were not carried out, the real-world payoff elements could only be estimated within some range for two reasons. Firstly, complementarity may exist between alternative acts. If complementarity is present, its effect will vary with the intensity of use of the relevant alternative transformation processes. Secondly, allowance must be made for errors of estimation. Hence the payoffs would not be single valued but multi-valued, perhaps having some associated probability distribution. If so, in evaluating such payoffs the decision maker might take account of higher moments of the payoff's probability distribution and not just the first moment as we have assumed. Allais (2) and Tintner (80) have postulated that higher moments are taken into account. If they are, and the question has not yet been satisfactorily answered, then our model is limited to this extent. However, as Dorfman, Samuelson and Solow (18, p. 431) stress, to take account of these higher moments would be difficult in an empirical analysis. Certainly there is strong precedent in economic analysis for considering only expected values. Admittedly this is not a justification for the assumption made, except in so far as this study is the first of its type.

It must be emphasized that each member of N' makes his choice in terms of a model similar in construction to this one, but differing with respect to the available alternatives and the partitioning of these alternatives and Nature's possible states.

The payoff matrix facing an entrepreneur $n' \varepsilon N$ is generalized below. This payoff matrix will vary in size and content during the planning period in so far as n' changes his conception of the situation. None the less, when a decision has to be made, it must be in terms of some such matrix of the type generalized below, if the model is correct.

$$
\begin{array}{c|ccccc}
\text{Considered alternatives, } A^{\circ}\text{, of } n' & \multicolumn{5}{c}{\text{Possible states of Nature}} \\
 & S_1 & \cdots & S_j & \cdots & S_m \\
\hline
A^{\circ}_1 & a_{11} & \cdots & a_{1j} & \cdots & a_{1m} \\
\vdots & \vdots & & \vdots & & \vdots \\
A^{\circ}_i & a_{i1} & \cdots & a_{ij} & \cdots & a_{im} \\
\vdots & \vdots & & \vdots & & \vdots \\
A^{\circ}_k & a_{k1} & \cdots & a_{kj} & \cdots & a_{km}
\end{array}
$$

Implications of the Model

Suppose such a simplified payoff matrix is constructed. What then? Does our model indicate how the decision problem might now be approached? The decision maker n' knows that the other members of N' taken individually can at best base their decision on some similarly simplified matrix. However, their payoff matrices will differ from his in terms of the alternatives available to each of them and the way in which they categorize these alternatives and those of Nature. Therefore, in terms of his payoff matrix, these individual selections by other members of N' are random. If N'' and N''' are large, the individual selections of $n''\varepsilon N''$ and $n'''\varepsilon N'''$ will also be random in relation to the payoff matrix of n'. These random individual selections when aggregated give the state of Nature which will prevail. Since the individual selections are random in relation to the payoff matrix of n', the "selection" of a strategy by Nature will also be random from the point of view of n'. If over time all of the relevant variables were constant, it might be possible to ascertain a probability distribution associated with the occurrence of the various states of Nature. Such a probability distribution could then be used in assessing the relative merits of the alternatives A^{o} facing n'. This cannot be done because it would be too much to hope for any such constancy to prevail in any real-world situation of the type discussed here.

If N'' or N''' are small so that the choices of $n''\varepsilon N''$ or $n'''\varepsilon N'''$ are not random, the payoff matrix will be partitioned in some way but within each sub-matrix the strategy of Nature will be randomly selected.

Nature's strategy choice being essentially random, the payoff matrix depicts a decision problem under absolute uncertainty, or as some have called such problems, a game against Nature.

As Arrow (5) and Debreu (17) have shown, it is theoretically possible to remove the uncertainty that prevails when

N' is large. This could be done by having markets in which claims are traded on each commodity for delivery at a future date, valid only in the event of a specified contingency. As Koopmans (45, p. 161) points out, the real world does not approximate this ideal although such markets do exist for securities and for a small number of highly standardized commodities.

While the model indicates that absolute uncertainty will exist, it says nothing of the possible magnitude of the effects of this uncertainty. These effects will vary, depending on the specific situation being considered. For some situations, it may be that the variations over the set of payoffs are so small as to be of little significance.

Summary

A model in terms of game theory was constructed. It was shown to be unreal, the game theoretic assumptions being too demanding. However, by realizing the implications of a freely competitive situation and assuming the entrepreneur to have less than full information and to follow some method of simplifying the complexity of the problem he faces, a more satisfactory model of the decision making situation was obtained. The logical implication of the model is that the decision problem is one under absolute uncertainty. It is asserted that this structuring of the decision problem is the most rational way to frame the problem in terms of a profit maximizing goal.

A number of theories applicable to decision problems under absolute uncertainty have been advanced. They are described in the next chapter.

III. THEORIES OF CHOICE UNDER ABSOLUTE UNCERTAINTY

Absolute uncertainty prevails when the decision maker has no objective knowledge about the likelihood of occurrence of the various possible states of Nature. Although he knows what alternatives are possible for Nature, he is genuinely ignorant of which of her alternatives she will follow. Some theories of decision making have been postulated specifically for such circumstances. Such are those of Wald, Savage, Laplace and Hurwicz. These will be outlined first. The more general theories of decision making of Simon and Shackle will then be described in so far as they relate to absolute uncertainty. No consideration will be given to the pioneering contributions of Hart (28), Hicks (33), Knight (43), and Tintner (80) beyond pointing out here that theirs were the first systematic approaches to the problem of uncertainty in economics.

The discussion throughout will be in terms of the generalized payoff matrix given on page 22. Except for showing the relationship between Shackle's theory and Hurwicz's approach and some comments upon Simon's theory, this chapter contains nothing original. It is merely a gathering together of the material to be found in the sources noted.

Decision Theories Specific to Problems of Absolute Uncertainty

The theories in this group have a number of common features. They have not been postulated as general theories. Each of them postulates a mathematical algorithm for selecting the best act, the best act being defined tautologically as that selected by the algorithm. Also, they are rational to the extent of being mathematically well-defined, the postulated algorithm in each case being precise and never leading to ambiguous selections under a given set of circumstances.

As Luce and Raiffa (48, p. 296) stress, there are no *a priori* theoretical grounds for prescribing one of these theories instead of another. Which is the preferred algorithm depends on the decision maker's predisposition and judgement. There is therefore no single best mathematical procedure for solving a decision problem under absolute uncertainty. Indeed an infinite number of well-defined algorithms are possible. However, it is doubtful that any more plausible criteria than those discussed below are available for normative analysis of empirical situations. Moreover, they are not so complex that it would be implausible for them to have a descriptive role for some decision makers.

Our exposition of these criteria will essentially follow that of Luce and Raiffa (48, pp. 278-286). We do not, however, consider all of the theoretical objections to each criterion which they elaborate.

Wald criterion

If only pure acts can be selected, the Wald or maximin criterion suggests selection of that act which has the maximum minimum payoff. If a mixed strategy is permissible and the payoff matrix has no saddle point, then that mixture of acts should be chosen which has the maximum minimum expected payoff. This criterion is equivalent to treating the problem as a two-person zero-sum game; a procedure that assumes the worst possible result will occur. Since Nature is playing a passive role and not actively trying to defeat the decision maker, the Wald theory is extremely conservative.

<u>Savage criterion</u>

This theory takes account of the regret that might be felt after the true state of Nature is known and it is realized that a larger payoff may have been obtained (67). The procedure aims at minimizing this regret. To this end a new payoff matrix, termed the risk or regret payoff matrix, is constructed from the actual payoff matrix $\left[a_{ij}\right]$. Each element, r_{ij}, of the regret matrix $\left[r_{ij}\right]$ is the amount that would have to be added to the original element a_{ij} in order to equal the maximum payoff in the j th column. Thus

$$\left[r_{ij}\right] = \left[\max_j a_{ij} - a_{ij}\right] . \tag{2}$$

If only pure acts may be selected then that act which minimizes the maximum regret should be chosen. If the regret matrix has no saddle point and mixed strategies are permissible, that mixture of acts which minimizes the maximum expected regret should be chosen.

An equivalent procedure is the application of the Wald criterion to the negative of the regret matrix. Like the Wald theory, Savage's criterion is conservative in assuming that the worst will occur; worst in this case implying the largest possible regret.

Hurwicz criterion

Sometimes known as the pessimism-optimism index criterion, this theory takes account of both the best and the worst payoffs for each act. In the form proposed by Hurwicz (36), it is as follows. Let β, a fixed number between 0 and 1, denote the decision maker's level of pessimism. With each act A_i° associate the index $\beta \min_j a_{ij} + (1-\beta)\max_j a_{ij}$. That act should then be chosen which maximizes this index. If the decision maker has no optimism, so that $\beta = 1$, then this procedure is equivalent to Wald's criterion. Thus the latter theory is a special case of Hurwicz's suggestion.

By leaving the explicit form of the pessimism-optimism index function unspecified, Radner and Marschak (64, p. 62) have given a more generalized form of the Hurwicz criterion. As is shown later, in a context of absolute uncertainty this generalized form subsumes Shackle's theory.

Laplace criterion

Oldest of all the decision theories to be elaborated is Laplace's principle of insufficient reason. This postulates that since there is no information about the likelihood of occurrence of the various possible states of Nature, the decision maker should act as though each of Nature's states has an equal chance of being the true state. The expected utility associated with an act A_i^o is therefore $\sum_{j=1}^{m} a_{ij}/m$ where m is the number of possible states of Nature. The act which has the largest expected utility should be chosen.

Savage's subjective probability theory

Not to be confused with his minimax regret criterion is a later theory of Savage showing how subjective *a priori* probabilities may logically be attached to the various states of Nature in a decision problem under absolute uncertainty. To do this he synthesizes de Finetti's (21) personalistic approach to probability and von Neumann and Morgenstern's (57, pp. 617-632) axiomatic approach to utility. Savage (66, pp. 6-104) has outlined at length the postulates underlying his approach. Koopmans (45, pp. 157-161) has given a very understandable paraphrase of them while Luce and Raiffa (48, pp. 300-304) have shown the relationship between the algorithms described above and Savage's subjective probability approach to absolute uncertainty. The essential distinguishing feature of Savage's theory is the postulate that a complete preference ordering of all acts exists for the decision maker, quite apart from any consideration of the payoffs relevant to each act. If this is so, an optimal set of subjective probabilities can be attached to Nature's states. The decision problem can then be handled in subjective terms as a risk problem (48, p. 277) - provided that only the expected value of the payoff distributions are considered by the decision maker.

This approach is normative. A decision maker following Savage's logic would base his choice on maximization of the expected utility of the consequences; such utility being derived not only from the payoff itself, but also from his preference for the act apart from its payoffs. In this sense, Savage's theory is an important contribution. It allows for the fact that utility need not be derived solely from money income. Commenting upon the theory's possible descriptive role, Koopmans (45, p. 159) says:

> Whether or to what extent these results have descriptive value is an empirical question to which the answer is not obvious........verification by observation of actual economic decisions appears difficult, whereas verification in experimentally created conditions may well be of limited relevance for explanatory theory.

While recognizing the importance of this approach, we will not attempt to assess the empirical role that it might play. To do so would have been impossible in terms of the resources available for this study. Our empirical analysis will be based on the assumption that the decision maker has no preference ordering among acts in his considered set of acts A^{o}. At least within this set of acts, choice on the basis of profit maximization is assumed to be dominant.

Simon's Theory of the Satisficer

A major feature of Simon's theory has already been incorporated in our model. It is that in complex situations the real-world decision maker simplifies the problem by considering not all possible alternatives but only some subset of them that is commensurate with his capabilities. One other postulate completes Simon's theory. It is that the decision maker behaves as a "satisficer", seeking a course of action that is "good enough", rather than as a maximizer seeking the best possible course of action (75, pp. 204 and 246-248). He argues that the decision maker has some aspiration level which he tries to attain. Any considered act whose outcome may lie below this level is regarded as unsatisfactory. In a given situation there may be a number of satisfactory considered acts. The first one of these to be studied may or may not be accepted. So long as the chosen act meets the aspiration level of the decision maker he is behaving in what Simon terms an intendedly rational manner (75, p. 200). This theory is, of course, descriptive and not normative.

Simon (75, pp. 201-204) is extremely critical of the game theoretic variants of decision making under absolute uncertainty that we have outlined above. He believes (75, p. 202) that such theories are wrong

> ...in seeking to erect a theory of human choice on the unrealistic assumptions of virtual omniscience and unlimited computational power.

He does not recognize, as our model does, that these assumptions of omniscience and unlimited computational power may be relaxed by accepting his hypothesis of simplifying the real-world problem and then applying the algorithmic procedures to the simplified version of the problem.

Shackle's Theory of Potential Surprise and Focus Outcomes

Stressing psychological variables, Shackle (69, 70, 72, 73) has postulated a theory of decision making for what he terms non-divisible non-seriable situations. That is, for decision situations where actuarially certain outcomes cannot be assigned. In such circumstances he believes it illogical to use mathematical probability (73, p. 38). He substitutes possibility or what he terms degrees of belief in its place. His rejection of probability in such decision problems has led to extensive discussion in the literature (4, p. 433, 23, 87). However, this discussion is irrelevant in a context of absolute uncertainty.

Shackle's degree of belief concept becomes operational in his theory through its relationship to potential surprise. The degree of belief a decision maker feels in a possible outcome is defined as corresponding uniquely with the degree of surprise which he feels himself exposed to if that outcome should occur.

In making a decision, Shackle theorizes that the decision maker considers each possible outcome in relation to its potential surprise, sighting for each act what he terms a focus gain-focus loss pair of outcomes. Graaf and Baumol (26, p. 341) and Arrow (4, p. 432) have criticized this distinction between losses and gains, a criticism accepted by Shackle (71, p. 346, 72, p. 49). We will therefore speak of focus best-focus worst pairs. These are the "good" and "bad" outcomes for each act which, when taken in conjunction with their associated potential surprise, have the greatest attention arresting power. By some conscious or subconscious method these pairs are standardized in terms of utility. The standardized pairs, one set for each act, are then evaluated, perhaps intuitively (60, p. 17), on the decision maker's gambling indifference system. The act whose standardized focus outcome pair lies highest on this loss versus gain indifference system will then be selected.

Such is Shackle's general theory. What becomes of it when absolute uncertainty prevails? In such circumstances the concept of potential surprise plays no role. With absolute uncertainty, maximum potential surprise must be attached to every possible outcome. The focus pairs then consist simply of the best and worst payoffs for each act, potential surprise playing no part in the ordering of the possible payoffs. It is these pairs that are evaluated in the decision maker's gambling indifference system. Hence, under absolute uncertainty, Shackle's theory devolves to an analysis of the situation rather close to that of Hurwicz. In fact, it is subsumed under the Radner - Marschak (64) generalization of Hurwicz's theory and includes Hurwicz's actual suggestion as a particular case. Arrow (4, p. 433) has already pointed out that Shackle's theory includes the Wald maximin criterion as a special case.

These relationships between Shackle's theory and the axiomatically derived game theoretic type of approach are interesting in that Shackle's theory has, in general, been well received by British economists and psychologists (11, passim) but not by North American economists (4, p. 433, 59, p. 701, 87) or psychologists (20, p. 402). Conversely, the game theoretic type of approach has received much attention in this country (45, p. 155, 48) but little commendation from English sources (72, p. 60). This dichotomy is very apparent in a comparison of two relatively recent conferences on decision making. The British conference (11) was devoted entirely to Shackle's theory with no direct references to the game theoretic type of approach while the report of the United States conference (79) stresses the latter approach but contains no mention of Shackle's contribution.

Shackle's theory is purely descriptive. It has no normative intent. For a given set of the relevant variables it may be considered as an algorithm for reaching a decision. However, its essential feature is the use of the psychological variable termed potential surprise and the gambling indifference system; together with the unspecified procedure for standardizing focus outcome pairs. These elements are not constant. They may change from what Shackle terms one "moment-in-being" (72, p. 13) to the next. Thus, in facing a given payoff matrix, a decision maker may decide on one act now and another in the next moment-in-being; all the while behaving in what Shackle would call a rational manner.

Stochastic Theories of Choice

With the exception of Simon's theory, all of the contributions outlined above imply that, given the decision maker's state of mind, there is some specific act(s) among the set A° that he should accept. Should he select some other act, he must be behaving illogically in the light of his own predispositions. As Åkerman (1, pp. 347-348) points out, the rules of behavior allow no randomness of response nor any countenance of free will or even libertarianism. In a normative context this does not matter. Descriptively it is important: a single observed inconsistency would lead to refutation of the theory in cases where the decision maker had a predilection for the particular theory being assessed. As Koopmans (45, p. 161) says in discussing Savage's subjective probability theory:

> Verification will need to be preceded by a certain relaxing of the postulates sufficient to accommodate natural variability of response but not going so far as to deprive the theory of all empirical content and descriptive value.

To this end a number of workers, notably Chipman (12), Luce (46), Marschak (50) and Papandreou (62), have formulated a number of probabilistic theories of choice. We will not consider these stochastic approaches in our empirical analysis beyond recognizing the general validity of the comment by Koopmans quoted above.

IV. ANALYSIS OF A SIMPLE PROBLEM

As an example of the functioning of the decision criteria to be considered empirically, we apply them here to the following decision problem under absolute uncertainty. This particular problem will figure prominently in the empirical analysis of Part II.

Decision maker's alternatives	States of Nature S_1	S_2	S_3	S_4
A_1	2,500	3,500	0	1,500
A_2	1,500	2,000	500	1,000
A_3	0	6,000	0	0
A_4	1,500	4,500	0	0

Wald Criterion

Using this algorithm, that act or combination of acts is sought which has the maximum minimum payoff. Inspection of the matrix shows that a saddle point exists at the a_{23} position with a payoff of 500. Hence A_2 should be selected.

Savage Criterion

When this criterion is used, the aim is to minimize the maximum regret that may be felt <u>ex post</u>. To this end the regret matrix is calculated as indicated in Equation 2. Hence we have for $\left[r_{ij}\right]$:

$$\begin{bmatrix} 0 & 2500 & 500 & 0 \\ 1000 & 4000 & 0 & 500 \\ 2500 & 0 & 500 & 1500 \\ 1000 & 1500 & 500 & 1500 \end{bmatrix}$$

If only pure strategies are allowed, A_4 must be selected for its maximum regret of 1500 is smaller than that for any other act. With mixed strategies permitted, the decision maker should use A_1, A_3, A_4; allocating his resources among them in the proportions of 9 : 23 : 68 respectively[1]. With such a mixed strategy his maximum expected regret would be 1365.

Hurwicz Criterion

The choice that should be made when this algorithm is used in the form suggested by Hurwicz is the act for which the value of $(\beta \min_j a_{ij} + (1-\beta)\max_j a_{ij})$ is a maximum, remembering that β is an index of the decision maker's level of pessimism and lies between zero and one. The minimum and maximum payoff values for each act are:

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[1]This solution is obtained by analyzing the negative regret matrix as a linear programming problem. Heady (29) has illustrated the method.

A_1 : 0, 3,500

A_2 : 500, 2,000

A_3 : 0, 6,000

A_4 : 0, 4,500

Since the minimum-maximum payoff pair for A_3 dominates those of A_1 and A_4, the choice will always lie between A_2 and A_3 regardless of the size of β. Which act out of A_2 and A_3 should be selected depends on the value of β.

If

(3) $$\beta(500) + (1-\beta)2000 > \beta(0) + (1-\beta)6,000$$

which implies

(4) $$\beta > 8/9,$$

then A_2 should be selected. If the inequality in Equation 3 is reversed, we find that for

(5) $$\beta < 8/9$$

A_3 should be selected. When

(6) $$\beta = 8/9$$

either A_2 or A_3, or some mixture of these two acts, should be selected.

Laplace Criterion

Since there are four possible states of Nature, the principle of insufficient reason says a probability of 0.25 should be given to each of these states. The expected value of each act is then:

A_1	:	1875
A_2	:	1250
A_3	:	1500
A_4	:	1500

A_1 has the maximum expected value and should be selected.

Simon's Theory of the Satisficer

If the decision maker had an aspiration level of zero, he would be satisfied with any of the four acts available. All of them guarantee at least a zero payoff.

With an aspiration level greater than zero, A_2 must be selected. This is so even if the aspiration level is greater than 500, for A_2 is still the best act; although in such a case the best of a bad lot.

Shackle's Theory of Potential Surprise and Focus Outcomes

Since absolute uncertainty prevails, the standardized focus outcomes are simply the pairs of best and worst payoffs for each act. Inspection shows that they are:

A_1	:	3500,	0
A_2	:	2000,	500
A_3	:	6000,	0
A_4	:	4500,	0

Acts A_1 and A_4 are dominated by A_3. The choice therefore lies between A_2 and A_3. Which of these is selected depends on the decision maker's gambling indifference system. The greater his disposition to gamble, the more likely it is that A_3 would be selected; the smaller this disposition, the greater the chance that A_2 would be chosen. At any rate, either A_2 or A_3 must be selected. A_1 or A_4 should never be selected.

Summary

Drawing together the analyses of this simple problem, we have the following solutions for each of the decision theories applied:

Wald criterion with only pure strategies	: A_2.
Wald criterion with mixed strategies	: A_2.
Savage criterion with only pure strategies	: A_4.
Savage criterion with mixed strategies	: $0.09A_1$; $0.23A_3$; $0.68A_4$.
Hurwicz criterion with $\beta \leqslant 8/9$	: A_3.
Hurwicz criterion with $\beta \geqslant 8/9$	: A_2.
Laplace criterion	: A_1.
Simon's theory with an aspiration level of zero	: A_1 or A_2 or A_3 or A_4.
Simon's theory with an aspiration level greater than 0	: A_2.
Shackle's theory	: A_2 or A_3.

V. RELATION TO PREVIOUS WORK

Theoretically, the most important feature of the model we have constructed is its implication that entrepreneurs operating in a freely competitive market, whose members have a number of production alternatives, must normally make their production decisions under absolute uncertainty. As was pointed out in constructing the model, Shubik (74) came close to this result in his analysis of the full information assumption of game theory. However, he did not realize the role of the aggregative maneuvers of the decision maker's opponents. Heady and Candler (31, p. 500) and Koopmans (45, p. 163) recognized such a possibility but have offered no substantiation of the hypothesis.

The empirical importance of the model lies in its indication of the role that theories of decision making under absolute uncertainty should play in such real world situations. It shows how the relevant decision problem might best be approached. Also, it offers an opportunity to assess empirically the normative and descriptive roles that the various theories we have outlined might play. Conversely, it provides a framework in which the malaffects of the foibles of real world decision makers, with their rules of thumb, habits and beliefs, might be measured. To date, such studies have not been carried out because of the lack of a suitable frame of reference. It is to this extent, then, that this study is original in its empirical analysis.

So far as can be ascertained, the literature contains no real-world analyses of the roles of the theories outlined in Chapter III. However, recent years have witnessed a proliferation of laboratory type experiments on decision making; conducted with a high degree of mathematical sophistication by a relatively small group of mathematical economists and psychologists. In the main, such studies have been concerned with the measurement of utility and of subjective probabilities and their role. Most important has been the work of Coombs and Beardslee (13), Davidson, Suppes and Siegel (16), and of Mosteller and Nogee (56); Chipman (12) and Papandreou (62) have studied stochastic models of choice experimentally while Flood (22) and Kalisch, Milnor, Nash and Nering (41), among others, have examined decision making in experimental games involving a small number of players. In general, such studies have approached the problem of decision making by considering the basic postulates underlying the various theories that have been proposed. They are fundamental rather than applied studies. As such, their results tend to indicate that people do have fairly consistent preference structures and tend to behave in a way consistent with these preferences.

There appear to be no experimental studies of the various theories in which we are interested, taken in *toto*. Numerous studies have been made of the expectations and reactions to uncertainty of entrepreneurs operating under free competition. By necessity, most such studies relate to farmers. However they never quite reach the problem of decision making in an analytic sense, mainly because of the lack of a suitable model. Nor do they show any appreciation of the normative or descriptive roles that might be played by the theories we have outlined. Typical of such studies is that of Morrison, Judge and Tompkins (55).

Mention should be made of an applied study by Wray (90) which is referred to by Shackle (72, p. 64), seemingly in support of his theory. Wray does not test Shackle's theory. Rather, she assumes its truth. Moreover, her attempt to explain entrepreneurial behavior on this basis is inconclusive.

Against the background of related work sketched above, a background lacking in real-world studies of the pertinent decision theories, we now proceed to the empirical analysis of Part II.

PART II. EMPIRICAL

VI. SOURCE AND COLLECTION OF THE DATA

The data to be analyzed were collected in the course of a four stage panel survey. This panel constituted a population of 77 farmers. As the schedules shown in Appendix B indicate, the survey was primarily oriented to farmer price expectations. Discussions were held with each farmer in June, August and October of 1957 and (by mail and telephone) in January, 1958.

Description of the Population

The population consisted of farmers who:

(1) were farming in Marshall County, Iowa;

(2) were aged between 30 and 50 years in June, 1957;

(3) had owned and operated at least 80 acres of farmland during the three years prior to June, 1957;

(4) had fed an average of at least 25 feeder cattle[1] in each of the three feeding seasons prior to the survey;

(5) cooperated in all stages of the survey.

Restrictions 1 to 4 were made so as to control possible tenure and age effects while guaranteeing that the respondents occupied a decision making role and had more than a modicum of experience in the feeder cattle operation. By making the

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[1]These are purchased cattle which the farmer fattens and sells for slaughter.

group more homogeneous than would otherwise have been the case, they permit a more clear cut analysis and give a greater chance that any important relationships will be discovered.

Marshall County is one of the more important in Iowa with respect to feeder cattle. It is in North Central Iowa and can be identified with the highly productive Central Corn Belt region. Somewhat less than one-half of the farms are operated by owners while the majority of the remainder are operated by regular tenants. The agriculture is diversified in terms of crops and livestock production although more income is from livestock than from crops. The amount of capital per worker is relatively high, and the farms are highly mechanized.

The means of some selected characteristics of the respondents are listed in Table 1. The left side column of

Table 1. Summary of selected characteristics describing the respondents

		Mean	
Characteristic	Unit	77 farmers	75 farmers[a]
Age	year	42.1	42.1
Dependents	no.	3.6	3.6
Formal education	year	11.6	11.5
Land operated	acre	291.4	260.2
Capital	$1,000	133.6	108.5
Equity	per cent	88.4	86.5

[a]The two farmers with extremely large farms are excluded.

figures refers to the population of 77 farmers. Included in this population are two farmers who had extremely large farm businesses relative to the other members of the population. In terms of acres operated, capital invested and gross income, their farm operation was twice the size of that of any other member of the population. The means of the selected characteristics are therefore also presented, in Table 1, with these two farmers excluded.

As noted above, the population was restricted to farmers between 30 and 50 years who were owner-operators of three years standing. For this reason the mean years of education, number of dependents, dollars of investment and per cent equity are probably somewhat higher than the comparable means for all farmers in the area.

Considerable variation existed among the 77 farmers in all the characteristics measured. Five of the 77 were professional men who had invested in farming while still maintaining their professional practices. Another two devoted the majority of their time to small-town businesses. Two operated large seed corn plants and one farmed as a sideline to general contract work. Only one farmer worked part time as a non-farm employee. At least one year of college had been completed by 17 of the farmers while 20 of the 77 had not completed high school. Seventeen had full-time non-farm work experience. Only 13 had not worked as farm laborers and 22 had never operated a farm as a tenant. Some rented land was farmed by 24 of the farmers. Sixteen had an equity of 100 per cent. Further details of the personal, financial and farm organization characteristics of the population are presented in Appendix A.

Survey Procedures

An initial list of 120 farmers who were thought to satisfy characteristics 1 to 4 of page 47 was drawn up. This was done with the aid of the Agricultural Stabilization and Conservation Committee of Marshall County. Originally, the aim was to interview a random sample of 70 from these 120 farmers. However, initial contacts indicated that there might be a large number of ineligible or uncooperative farmers. Since a multi-interview survey was planned, it was decided to contact all of the farmers listed; thereby ensuring a satisfactory number of completed schedules over all stages of the survey. The initial survey indicated that 95 of the 120 farmers were eligible while two additional members of the population were found. Of these 97 farmers, 18 refused to cooperate at some stage of the survey. Another two were unavailable. The number of cooperating farmers at each stage of the survey was as follows:

First stage: 85

Second stage: 82

Third stage: 77

Fourth stage: 77

It appears that the number of respondents had become fairly constant at the completion of the third survey. Nothing is known about the 12 farmers who would not cooperate at the first stage of the survey. In terms of the data collected in the first survey, there appear to be no marked distinctions between those who later refused to cooperate and those who did cooperate. However, this may not be true with respect to their decision making characteristics. Certainly, in deciding not to cooperate they made one decision quite distinct from those who did acquiesce! Therefore, only the data provided by the 77 farmers who cooperated throughout all stages of the survey will be analyzed.

The applicability of the study in its empirical aspects could have been extended by drawing a stratified random sample over a number of counties. This was not feasible because of financial and interviewing time restrictions related to the price expectation side of the study. If it had been possible, an even better extension of the analysis would have been to examine one or more other decision problems under absolute uncertainty.

The questionnaires

The personal interview using a questionnaire poses a number of problems. Most serious are those related to memory bias on the part of the respondent, interviewer bias, and communication between the interviewer and the respondent. Memory bias was not a serious problem in this study, the majority of the relevant questions not being about the past[1].

Ambiguity in communication was a more serious problem. It may arise from two sources: ambiguity in the question and ambiguity in the answer. Several steps were taken to reduce the possible ambiguity of the questions. The first consisted of unstructured interviews with three farmers who had a feeder cattle enterprise. The objective was to obtain some idea of farmers' expressions and word use in relation to the feeder cattle enterprise. This information was of aid in wording and structuring the questionnaires.

Formulation of the first stage questionnaire was the next step. A draft was pre-tested on three farmers. After the pre-test the questionnaire was reworked, account being taken of comments by Professors Howell, Kutish and Heady of this Department. The schedule was then pre-tested again on two farmers, and became, with a few slight changes, the schedule for the first survey. The questionnaires for later stage surveys were not pre-tested; sufficient knowledge of

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[1]The questions are reproduced in Appendix B.

the farmers' frames of reference and of the communication problems involved having been obtained in the first survey to ensure the formulation of satisfactory follow-up questionnaires.

In an interview, ambiguity of response may occur when the respondent has low ability to give a pertinent and coherent answer. Also, the interviewer may not understand the implicit basis of the answer. Efforts were made to overcome these exigencies by asking the respondent to elucidate his answers and by repeating the question with more interpretation. So far as the latter technique presents more stimuli to some respondents than to others, it is bad.

Interviewer bias

Because it was desired to complete each stage of the survey within the smallest possible time, a number of interviewers were used. There were three for the first survey, five for the second and three for the third. Three interviewers assisted in all three of these personal contact surveys. Before commencing field work, each interviewer was instructed in detail on the aims and implications both of each question he had to ask and of the over-all study; also, on the general conduct of an interview as suggested by Cannell and Kahn (10). Every interviewer was accompanied by the author on his first one or two interviews. All completed schedules were checked for irregularities that may have arisen through interviewer bias or mistakes. This was done within a day of their completion. Where anomalies existed, the respondent was contacted again and the query clarified. It is hoped that interviewer bias was reduced to a minimum by the use of these procedures.

A check on responses to one of the most important questions strongly indicates that interviewer bias was not present. The data analyzed are shown in Table 2. The question to which

Table 2. Number of alternatives considered by farmers as determined by each interviewer

Interviewer	Number of alternatives considered	Number of farmers
A	1, 1, 1, 2, 2, 2, 2, 2, 2, 2, 2, 3, 3, 3, 4, 4, 5	17
B	1, 1, 2, 2, 2, 2, 2, 2, 2, 2, 2, 3, 3, 4, 4, 5, 8	17
C	1, 1, 2, 2, 2, 2, 2, 2, 2, 3, 3, 3, 3, 4, 4, 5	16
D	1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 4, 5, 7	14
E	1, 1, 1, 2, 2, 2, 2, 3, 3, 4, 5, 5, 7	13

it relates is probably, of all those asked, the one most likely to be subject to interviewer bias[1].

Bartlett's test for homogeneity of variance, as outlined by Snedecor (76, p. 287), was applied to test if the interviewing samples had the same population variance. This as-

[1]The question is number IX: 1 of Schedule B, Appendix B.

sumes a random distribution of respondents among interviewers - an assumption that was not fully satisfied with regard to the geographic locations of the respondents within Marshall County. It does appear to be satisfied for other attributes of the respondents. Bartlett's test was applied to a transformation of the data. The transformation used was from x to $(x+1)^{\frac{1}{2}}$. This was done because counts of a discrete variable, such as the one considered here, tend to follow a Poisson distribution as Snedecor (76, p. 315) has noted. The test supported the hypothesis that the variances of the interviewer samples were not significantly different.

The data were also tested to see if significant differences existed among the interviewers with regard to the mean number of alternatives elicited by each. As for the previous test, a transformation of the data to $(x+1)^{\frac{1}{2}}$ was carried out before applying analysis of variance (76, p. 269). This test strongly supported the hypothesis that the means were the same[1].

Since these tests indicate that significant differences did not exist among the means or variances of the interviewer samples, it is concluded that the precautions taken to prevent interviewer bias were satisfactory.

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[1]As would be expected, the mean and variance of a Poisson distribution being identical.

VII. ASSESSMENT OF THE THEORETICAL MODEL

We have constructed a model of the production decision problem facing an entrepreneur operating under free competition. In this chapter our aim is to assess the descriptive role of this model. Ideally, it would be desirable to make the appraisal in a number of decision making contexts. This has not been possible. We shall appraise the model in only a single decision making context - that of a Mid-West farmer in his consideration of feeder cattle as a possible enterprise in a given season.

The Feeder Cattle Pre-Purchase Decision Problem

The decision problem facing such a farmer has two broad components. Firstly, how large should the feeder operation be? Secondly, what type(s) of feeder program should he follow?

Although not strictly true, it is a useful simplification to think of these problems as being independent. For a given bundle of resources, the price relationships between the beef and other possible enterprises determine how large the feeder enterprise should be. The problem of what type(s) of feeder program to follow becomes a decision problem within the feeder enterprise. Under conditions of certainty, this dichotomy would be a false one. However, the feeder cattle enterprise is a risky one relative to other enterprises possible on Mid-

West farms. One livestock expert (7, p. 327) has described it as

> .....not a business, but a disease or vice - something within the law in which you can engage if your wife objects to poker or the races.

It is also an enterprise requiring specific managerial skills (7, passim, 54, pp. 776-808), and, in most instances, a sizable fixed investment in cattle housing, feed lots and ancillary feeding facilities (7, p. 387, 39). For these reasons the separation of the decision problem into two parts - choice within the feeder enterprise and choice between the feeder and other enterprises - is a justifiable analytic simplification in an exploratory study such as this. In our analysis we consider only the decision problem within the feeder enterprise in a given season. Moreover, the analysis is restricted to the planning situation of the farmer. No consideration is given to the specific market situation he faces when he actually enters a buying or selling market where decisions, made with a minimum of reflection, may be forced upon him (40, pp. 68-69).

Within the feeder enterprise, the general pre-purchase decision problem facing a Mid-West farmer is as follows. Between July and December he must buy feeder cattle from the (Western) feeder raisers. These cattle will be fattened for sale. This operation may vary in terms of the age and sex of the cattle bought, their purchase weight, quality and date, the feeding program followed, the length of the fattening period or selling weight of the cattle, and their quality when sold. Additional variables are the location of the buying and selling markets and the degree of personal entry into these markets. In selecting a feeder program, a decision has to be made as to which combination(s) of these variables would be best for him to use. The questions the farmer must pose for himself are: What type of feeder cattle program should I follow in the coming season? If I should have a number of programs, what should their relative proportions be? These questions may be answered by default. Such would be the case for a farmer who followed some habitual feeder program.

Specification of the Model

This decision problem must be related to our model. The transformation process we are concerned with is that for the feeder cattle input. This is the generic input. It may take a variety of specific forms in terms of the age of the cattle, their quality, breeding and previous management. The generic output is fat cattle and this output also may take a variety of forms in terms of quality, weight and date of selling.

The economic hierarchy

The hierarcheal groups relevant to the decision problem within the feeder enterprise may be specified as follows, using the same symbols as before:

N' : the group of all farmers who may be expected to have a feeder cattle enterprise. The order of N' is approximately 500,000[1].

N" : the set of economic decision makers above N' in the economic hierarchy relevant to feeder cattle. This set is composed of three broad groups. In ascending order they are the meat packers[2], the retailers and the consumers (83). While there are only relatively few meat packers, there are thousands of retailers and millions of consumers.

N'": the set of economic decision makers below N' in the economic hierarchy relevant to feeder cattle. This set is essentially composed of the ranchers who raise the feeder cattle. Its order is approximately 200,000[1].

Regarding cattle as the generic input and output, N', N" and N'" satisfy the chain arrangement underlying our model. For all practical purposes these three sets are disjunct.

Nature's alternatives

Consider first the possible role of the meat packers and

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[1]Exact figures are not available. The figure given is based on the 1954 census of agriculture (82, p. 473).

[2]In general, the meat packers act as wholesalers by selling direct to retailers.

of the meat retailing and consumer groups. As the final link in the chain, it is the consumers who determine the demand for beef. Over a period of years, the most important factors influencing the aggregate demand schedule for beef are the number of consumers, their tastes and disposable incomes and the price of other meats (24, pp. 14-17, 89, pp. 80-87). With respect to a given production season, the consuming population with its tastes is relatively fixed (34, p. 63). Also, Fox[1] has recently shown that when account is taken of unemployment compensation payments and the progressive structure of personal income tax rates, there is very little within-year variation in disposable income. This was true even for recessions of the magnitude experienced in 1949, 1953 and 1957. Indeed, by Fox's calculations, none of these recent recessions led to a change in aggregate disposable income of more than two per cent.

For these reasons, variations in the quantity of beef demanded, relevant to the short-run of a single production period, are primarily related to changes in the price of beef and of other meats; apart from minor predictable fluctuations due to religious and other customs. These price-induced varia-

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[1]Fox, K. A. Department of Economics and Sociology, Iowa State College, Ames, Iowa. Variations in disposable income. Private communication. 1958.

tions in the quantity demanded will in turn affect beef prices. However the dominant cause of changes in the month to month price of beef is the supply of beef. Why? Because in the fresh unfrozen form generally preferred by consumers (77, p. 6), beef is a highly perishable commodity. It has to be moved quickly from the saleyard to the table. In fact, most beef is consumed within 14 days of slaughter (77, p. 6). Most importantly, within a given year, the current supply of beef relevant to current demand is a given or predetermined variable. Moreover, competition among the meat packers in supplying marketing services forces them to accept the quantity of fat stock offered for sale at any particular time (14). Because of its perishable nature, the wholesale and retail prices of beef must be adjusted to this supply if the supply is excessive. A rather similar situation prevails for other meats.

In such short-run circumstances, it is not so much the consumers who influence meat prices as that attempts are made, through meat price variations, to influence the consumers. The necessity for this arises because of short-term fluctuations - from week to week and month to month - in the number of livestock supplied for slaughter. In the short-run this supply is not influenced by the current actions of the packers, the retailers or the consumers. It is a function of the decisions made by the thousands of livestock producers; decisions made not so much under the influence of current circumstances as under the influence of conditions some months in the past and of prior expectations of current conditions (14). Thus the primary influences causing within-year variations in fat cattle prices emanate from the supply side. The role of the meat packers *per se*, and likewise of the retailing and consuming groups is negligible. It is the farmers who "deal the cards". Given the deal, the packers, retailers and consumers have to play accordingly.

The above analysis shows that, strictly speaking, producers of other types of livestock, as well as those producing fat cattle, affect fat cattle prices. Hence they influence the payoffs facing the farmer in his feeder cattle decision problem. None the less, in the short-run, the major influence on fat cattle prices comes from the supply of fat cattle. Account must be taken of this feature of the situation. However, following Beresford (7, pp. 324-329), no consideration will be made of the role of the producers of other types of livestock in our specification of the model. Their role is ancillary to that of the feeder fatteners. Also, we are considering the feeder cattle pre-purchase decision problem. This problem is faced from four to 14 months prior to the time when the fat cattle will be sold. The farmer therefore has ample time to adjust his feeding program to the expected effects of the producers of other types of livestock. Such adjustments could involve any of the selling specifications - weight, quality and date of sale - of the program(s). Given human capabilities, this seems a reasonable approach to the decision problem at the pre-purchase stage. Hildreth and Jarrett (34, p. 105) have suggested that such behavior does occur.

Specifying the model in such fashion, it is the aggregated choices of the other farmers considering a feeder cattle enterprise and of the feeder cattle raisers that determine Nature's strategy. Countenance must also be taken of the weather. It plays an important role through its effect on feed production, both grain and roughage. This has been shown by Cox, Eisenach and Mitchell (15, p. 9) and Kohls and Paarlberg (44, p. 15). The former found that 76 per cent of the year to year variation in the number of cattle on feed could be explained in terms of corn production; a variable largely determined in the short-run, as Fox (24, pp. 34 and 37) has stressed, by the weather.

The set S of possible states of Nature thus consists of all possible combinations over the ranges of the aggregative manuevers which might be followed by the feeder raisers in aggregate, all the other beef feeders taken in <u>toto</u> and the weather. Obviously, Nature's strategy selection will affect the individual decision maker but not <u>vice versa</u>.

Our model postulates that the decision maker partitions this set S into subsets S_j, each such subset being considered as a single broad alternative. The actual form of this partitioning will depend on the decision maker. The practical necessity for such a simplification of the problem is obvious, for S is an infinite set since climatic effects may occur over some continuous range.

<u>The decision maker's alternatives</u>

Some mention has already been made of the alternative acts available to the decision maker. The feeder cattle program may vary in terms of the age and sex of the cattle bought, their purchase weight, quality and date, the feed program followed, the length of the fattening period or selling weight of the cattle and their quality when sold. The set A of alternatives available to the decision maker is the set of all possible combinations of these variables, each taken over its range of possible values. The set A is therefore of infinite order, some of the listed variables being continuous. Weight and age at purchase and weight and age at sale are such variables. Hence the necessity for simplifying this set is easy to see. For instance, consider one of the decision variables - say purchase weight. To discriminate between programs on the basis of a one pound difference in the average purchase weight of the cattle involved, <u>ceteris paribus</u>, would be meaningless. Such a small difference does not matter. Even if it had some significance, it would lead to an immense number of alternatives. The result would be a choice problem beyond human capabilities. At the other extreme, the comparison of programs without regard to purchase weight would mean neglecting an important factor.

Some compromise grouping of the possible alternatives under each decision factor is warranted. Such a simplifying procedure would lead to the set of broad alternatives whose general element is designated by A_i. This set of broad alternatives perceived by the decision maker will vary from individual to individual. However, it might be expected to be a set of alternatives with practical significance, being finite and containing feeder programs in the form and with the implicit range of variation usually found in common reference to the feeder enterprise.

Some subset, which we designate A^o, of this set of broad alternatives will be considered by the farmer in his planning for the forthcoming production period. This subset may be delimited by the farmer on the basis of habit. More rationally, it might be based on some detailed longer-run assessment of the situation in terms of trends in consumer demand, the risks involved and his personal goals and resource restrictions.

The payoffs

The model stipulates that the considered acts, A_i^o, will be appraised in relation to the broad alternatives, S_j, available to Nature. This appraisal will be based upon the payoff element a_{ij} relevant to each act A_i^o and state of Nature S_j. For a rational analysis of the problem, these payoff elements must be comparable. This could be achieved in the present context by considering as payoffs the expected annual net per cent return accruing to an investment in each of the considered acts. This return is determined by the expected price of feeder cattle, the estimated cost of fattening the cattle and the expected price of fat cattle. Account must also be taken of the length of the feeding program and of alternative investment of the feeder enterprise capital when it is not invested in feeder cattle. The method of combining these variables so as to derive comparable payoffs is described in Appendix E.

Since cattle buying and selling prices and fattening costs vary over the possible states of Nature, the payoffs will, in general, vary over the payoff matrix. They will also differ from one decision maker to another due to varying specifications of the alternatives considered and of Nature's possible states; and because expectations will vary from one individual to another.

Uncertainty Implications of the Specified Model

For all practical purposes, the group of feeder cattle fatteners and the feeder raiser group both operate under free competition. As one analysis of these livestock markets describes the situation (35, p. 3):

> Price differences, except those caused by freight differentials and various marketing costs, do not last long. This is true of terminal as well as local markets. If one market becomes much higher than the other, it attracts more livestock and the price falls to the general level; if the price at one market works substantially lower than surrounding markets, receipts will drop off and prices go up.

This price behavior, combined with the fact that the individual feeder raiser or fattener normally has no significant influence upon the market price (19, p. 344, 63, p. 5), indicates that the buying and selling of cattle occur under conditions of free competition. Hence, by the implications of the general model we have constructed and shown to be capable of specification in terms of the feeder cattle decision problem, the decision problem within the feeder cattle enterprise is a problem under absolute uncertainty.

The Role of Outlook Information

There is, however, one aspect of the beef feeder decision problem that has not been mentioned so far. To wit, the role played by outlook information. The general model we have constructed makes no provision for such information - for two reasons. Firstly, such information is generally not freely available. Agriculture is an exception in this regard, the provision of such information being undertaken by public agencies such as the U. S. Department of Agriculture and the Land Grant Colleges. Secondly, such information may itself lead to uncertainty if sufficient individuals accept the information at its face value (27). It is noteworthy that this outlook information is couched in aggregate terms - an implicit recognition of the importance of the aggregated choices of the individual decision makers.

So far as Mid-Western feeder raisers are concerned, the primary sources of cattle outlook information are two publications of the U. S. Department of Agriculture's Agricultural Marketing Service (84, 85) and one of the Extension Service of Iowa State College (38). The information contained in these publications is made available to farmers through a variety of media - newspapers, farm journals, radio, television and agricultural consultants. It would be difficult for a farmer to avoid all contact with such information. This being so, an important question relevant to our model is raised. Namely, to what extent does such information negate the implication of the model that absolute uncertainty prevails in the prepurchase decision problem within the feeder cattle enterprise? The answer to this question involves empirical data. It will therefore be considered conjointly in the next section with other data pertinent to an assessment of the model.

It remains now to assess the normative model, attempting to see if it may have any descriptive value. In other words, do farmers approach the decision problem within the feeder cattle enterprise in some fashion akin to the model we have outlined?

Assessment of the Model

In making this appraisal we will use data collected from the population of 77 farmers described in Chapter VI and Appendix A. Since the group of farmers questioned constitute the whole population, statistical analysis as normally applied to sample data is not necessary. In so far as conclusions can be made about the population, they can be made directly from tabulations of the data. In this way we will now consider the evidence relevant to the hypothesis that our normative model has descriptive value.

Discernment of alternative acts

No attempt was made to ascertain the farmer's cognizance of the infinite set A of all possible feeder programs. It was obvious that all thought in terms of much broader alternatives than those that would constitute this set. Accordingly, the farmers' discernment of alternative acts was first considered systematically at the level of the broad alternatives, A_i. These are the alternatives that constitute a partitioning of the set A.

Theoretically, this partitioning might be approached in two ways: in terms of the overall programs or by way of the attributes specifying each program. As would be expected, preliminary discussion during the first stage survey indicated that the program by program approach was impractical. The set of discerned alternatives is too large to be enumerated verbatim. The approach through the decision variables - age type of cattle, purchase weight, date and quality, feed program and selling weight, date and quality - was therefore adopted. The problem is at what levels of the various decision variables does a farmer discern one program as being distinct from another? In what fashion are the decision variables stratified, if at all?

In varying degrees, the farmers did stratify the decision variables; the typical groupings made for each decision factor are shown in Table 3. Purchase weight, for example, was commonly grouped by 50 pound intervals so that the average farmer distinguished five steer calves programs with respect to the average purchase weight of the calves. While some farmers made finer distinctions and some broader ones, especially in relation to quality and feed program alternatives, the pattern of simplification is clear. No farmer's discernment of alternatives was so different from the general assessment shown in Table 3 as to be worthy of comment. Moreover,

Table 3. Farmers discernment of alternatives within the feeder cattle enterprise

Decision factor	Commonly discerned alternatives within each decision factor	No. of alternatives within each decision factor
Age type	steer calves, heifer calves, yearlings, two-year olds	4
Purchase weight	by increments of 50 lb.	
	steer calves: 300 - 550 lb.	5
	heifer calves:300 - 500 lb.	4
	yearlings : 550 - 750 lb.	4
	two-year olds:800 -1000 lb.	4
Purchase quality	medium, good, choice, fancy	4
Purchase date	by months	5
Fattening period	by months	
	steer calves: 8 - 14 months	6
	heifer calves:7 - 12 months	6
	yearlings : 6 - 11 months	5
	two-year olds:3 - 7 months	5
Feed program	dry lot	2
	pasture	1
Selling quality	good, choice, high choice, prime	4

no farmer appeared to have difficulty in understanding the questions relevant to this discernment of alternatives. This is taken as evidence that the noted levels of stratification are indicative of the average farmer's train of thought.

The pattern of simplification exhibited by the data of Table 3 shows close correspondence to that typically used in newspaper and other farmer oriented reportings of the cattle market. Perhaps the farmers were merely reiterating these oft used distinctions. If so, it would not matter; this would merely enhance the evidence that the set A is partitioned into some more practical and simpler set of alternatives as postulated by our model.

However, even with the level of stratification indicated in Table 3, the set of all possible combinations among the decision factors is unmanageable. Indeed, from Table 3 it should be possible to specify 22,560 alternative feeder cattle programs that could be distinguished by the typical farmer interviewed. Obviously no farmer could consider so many alternatives in planning his feeder enterprise. Although he could discern that they differed, it would be impossible for a farmer to evaluate so many possibilities.

The evidence gathered indicates that this set of discernible alternatives is further reduced by two processes. Firstly, a longer run decision appears to be made (sometimes by default) as to which of these alternatives will be considered over the shorter run of a few years. Although no attempt was made to study this longer run decision, farmer comments indicated that it is greatly influenced by the farmer's risk feelings, experience, and resource limitations. Thus quite a few farmers prompted that they never considered two-year old feeder cattle because they were too risky. Others commented that they considered only calves because they were generally sure of at least getting their capital back from such an investment. The second method of reducing the number of alternatives to be considered consisted of a further broadening of the strata relevant to some of the decision variables. This applied especially to those factors relating to the selling specifications of the program.

That these processes were carried out by the farmers was evidenced by their responses to the question: In planning your feeder cattle enterprise, what alternative feeder programs do you normally give consideration to?

These possible programs were specified in terms of the age type of feeders bought, their quality, weight and month(s) of purchase, the feed program to be followed and their grade, weight and month(s) of sale. The specific programs nominated by each farmer are listed in Appendix C. So far as we are concerned at this juncture, the essential feature of these responses is the number of alternative programs mentioned by each farmer and the level of stratification exhibited in these alternatives.

Consider first the number of distinct alternatives mentioned by each respondent. Since these alternatives constitute the set A^{o} of considered acts, their number is the order of A^{o}. Table 4 gives, in frequency distribution form, the order of A^{o} for each of the 77 farmers.

While the information collated in Table 3 indicates every farmer realized that there was an extremely large number of

Table 4. Frequency distribution of number of pre-purchase alternatives considered by farmers

Number of alternatives considered	Number of farmers
1	13
2	33
3	14
4	8
5	6
6	0
7	2
8	1
Total	77

alternatives, Table 4 shows that only four per cent considered more than five alternatives in the short-run. For the 17 per cent who had only a single program in mind, the short-run prepurchase decision problem was trivial. Their selection was habitual. The modal number of alternatives considered was two, 43 per cent of the farmers considering only a pair of alternatives. Compared to the order of the average discerned parent set implicit in the data of Table 3, it is obvious that the subsets A° classified in Table 4 are remarkably small.

Table 5 shows the extent to which the quality, weight and date of buying and selling were broadened by the farmers in specifying their considered alternatives. The feed program

Table 5. Ranges in quality, weight and date of buying and selling cattle specified in considered alternatives

Decision variable	Specified range of decision variable	Per cent of considered alternatives falling in each range	
		Buying	Selling
Quality	single grade	80.5	82.9
	two grades	19.5	17.1
Weight	zero	73.6	35.6
	50 lb.	9.8	7.8
	100 lb.	15.1	46.8
	150 lb.	0.5	4.4
	200 lb.	1.0	4.4
	250 lb.	0.0	1.0
Date	1 month	61.4	41.9
	2 months	21.5	30.2
	3 months	13.2	24.4
	4 months	2.4	3.5
	5 months	1.5	0.0

variable is not referred to explicitly in the table. However, a range in the specification of weight, quality or date implies a range in the feed program.

Perusal of Table 5 indicates that weight and date of buying and selling were most frequently broadened, especially in specifying the selling characteristics of a program. Seemingly, the farmers felt less sure about the selling environment than about the buying environment. In consequence, they made their considered alternatives more flexible in terms of selling than of buying characteristics. Overall, 205 considered acts were nominated. The following figures show the percentage of these considered programs that contained a broadening of at least one, two or three of the buying and selling decision factors listed in Table 3:

No. of decision factors broadened	Buying factor	Selling factor
	per cent	per cent
At least one	57	80
At least two	23	48
At least three	3	9

Of the 77 farmers, 70 specified a range of some decision variable in at least one of their considered alternatives. Fifty-six broadened at least one variable in each of their considered alternatives. There is therefore abundant evidence that the farmers simplified their decision problem, not only by abstracting some small number of discerned alternatives, but also by amalgamating a number of these alternatives in terms of the individual decision factors.

To gain some indication of the reliability of the farmers' statements of the composition of the set A° of considered acts, the alternatives mentioned were checked against a previous statement by each farmer of his plans for the current season. In only one case out of the 77 did the current plan include a program not specified in the subset of short-run alternatives. Further inquiry indicated that this plan entailed a prior commitment and was, in the current situation, a forced decision.

Thus in terms of the way in which the farmers discerned and reacted to the acts available to them, they did so in a manner completely in agreement with that postulated by our normative model. At least in this regard, the model has descriptive value. Simon's hypothesis has been strongly substantiated. Our real-world decision makers did simplify a complex range of possible acts to a degree compatible with their capabilities.

What of the other aspect of our model, that of the states of Nature?

Discernment of Nature's alternatives

In this regard, the first question to be considered is the extent to which the farmers conceived of Nature's strategies as being determined by the aggregative actions of all other beef feeders, the feeder raiser group and the weather.

All of the 77 farmers recognized the weather as an important influence. As regards the feeder raisers and other farmers fattening feeder cattle, the farmers' thoughts are presented in Table 6. This table shows the various ways in which the farmers conceived the prepurchase situation in terms of these other entrepreneurs as opponents in what might be called the beef feeder game. Each category of the table is exclusive. Summarization indicates that 71 of the farmers had some conception of an opposition: 59 in a form involving some grouping and 12 in terms of individuals. The influence

Table 6. Farmers' conception of their opponents in the beef feeding game

Conception of opponents in addition to the weather	No. of farmers
No conception	6
All other beef feeders individually	9
All other beef feeders as a group	7*[a]
Meat packers as a coalition	4
Meat packers as a coalition sometimes	2
Meat packers as a coalition within markets	3
Feeder raisers as a group	2
All other feeders individually, feeder raisers as a group	2
All other feeders as a group, feeder raisers as a group	3*
Meat packers as a coalition within markets, feeder raisers as a group	1*
All other feeders individually, packers individually	3
All other feeders individually, packers in coalition sometimes	6
All other feeders individually, packers in coalition within markets	3
All other feeders grouped, packers individually	1*
All other feeders grouped, packers grouped	3*
All other feeders grouped, packers grouped sometimes	3*
All other feeders grouped, packers grouped within markets	3*
All other feeders individually, packers individually, feeder raisers grouped	2
All other feeders individually, packers in coalition, feeder raisers grouped	1
All other feeders individually, packers in coalition sometimes, feeder raisers grouped	3
All other feeders grouped, packers individually, feeder raisers grouped	2*
All other feeders grouped, packers in coalition, feeder raisers grouped	4*
All other feeders grouped, packers in coalition sometimes, feeder raisers grouped	2*
All other feeders grouped, packers in coalition within markets, feeder raisers grouped	2*
Total	77

[a]An asterisk is used to denote those farmers who had a conception of the situation not very different from our specification of the theoretical model.

of other feeders in some fashion was recognized by 59 of the farmers; of meat packers by 48; and of the feeder raisers by 24 of the farmers. Not shown in Table 6 is the fact that one farmer mentioned the consumer group as a segment of his opposition. Another specified all livestock producers as an opponent. This farmer is included among the three who may be said to have visualized the situation exactly in terms of the theoretical model as we have specified it. That is, with a combination of the weather, a feeder raiser group and a group of all other beef feeders constituting the basic determinants of Nature's possible states. With some degree of subjectivity, 31 of the farmers had pictures of the situation approaching the normative model rather closely. These farmers are indicated by an asterisk in Table 6.

The data of Table 6 were obtained during the second stage survey by letting the farmers read the questions numbered VIII: 1-4 of Schedule B as shown in Appendix B. They were then asked for their opinions. Among these questions, there is no mention of feeder raisers. This is a purposeful omission, designed to provide a check on the farmers' responses. If the farmer did not mention the feeder raisers, he was asked about them after he had answered the listed questions. Nineteen farmers mentioned feeder raisers on their own initiative. An additional five admitted their influence when questioned specifically on their role. It would seem that the data gathered are fairly reliable.

To gain some idea of how operational these concepts of an opponent might be, and as an additional check on the original answers, the farmers were later asked an open-ended question as to which factors were most important in determining the type of feeder program they followed. As this was done in the third-stage survey, it is unlikely that answers were biased by memories of responses given to the related questions of the second stage survey. The data are tabulated in Table 7. It shows the frequency with which each of the listed factors was mentioned either as a primary or secondary determinant of choice. Fifty-four farmers mentioned only a single factor; 23 nominating two factors. It is noteworthy that no farmer mentioned any other specific farmer as influencing his choice. It would seem that no farmer played the role of a leader among the population.

Nineteen of the farmers placed major emphasis on some aspect of their feed supply, the primary short-run determinant of which is the weather. Some aspect of expected cattle prices, either buying or selling, was given primary consideration by 28 of the farmers. One nominated the purchases made by other farmers with feeder programs. These responses are quite compatible with our conception of Nature since the main determinant of cattle buying and selling prices is the aggregate actions of the feeder raisers and the other farmers

Table 7. Factors nominated by farmers as influencing their choice of programs within their feeder cattle enterprise

Factor influencing choice	Number of times mentioned as: Primary factor	Secondary factor
Expected personal supply of grain and roughage	10	4
Expected personal supply of grain	1	0
Expected personal supply of roughage	8	4
Expected buying price of feeder cattle	14	3
Expected buying and selling prices of cattle	9	2
Expected selling price of fat cattle	5	2
Expected corn price	0	1
Feeder cattle purchases of other farmers	1	1
Amount of risk involved	21	6
Force of habit	8	0
Total	77	23

who buy feeders.

There were eight farmers who said they selected their programs on some habitual basis. Reference to their considered alternatives indicated that two of these farmers considered only a single feeder program while five considered two alternatives. A check of these stated alternatives against the history of their feeder enterprise over the prior two years and their current plans showed that six of them did indeed have a common selection over the three years. For the other two a habitual selection did not appear to have taken place. It seems most likely that these eight farmers did not think in terms of an opponent, at least in the short-run.

Of the 21 respondents who mentioned risk as a major influence on their choice, seven considered only a single alternative, another seven two alternatives and the remaining seven at least three possible programs. Excluding those with a single alternative, four considered only calf programs, seven gave some consideration to yearlings and three included two-year old cattle as one of their alternatives. There is abundant evidence that calves are the least risky of feeder programs and two-year olds most risky (7, p. 327, 49, p. 5). It thus appears that those 10 farmers mentioning risk who considered more than one alternative and included a yearling or a two-year old program among these alternatives, did not mean to imply that they considered only less risky alternatives. Rather, they considered their alternatives in the light of the risk associated with each alternative. This was also indicated by the actual past and present selections made by these 10 farmers. They were quite diverse. Hence, these farmers may have been acting in accordance with our hypothesis. Nature may have played some part in their considerations.

Tallying these results, we see that only 19 of the 77 farmers responded to the open-ended question on factors influencing their feeder choice by mentioning a primary determinant incompatible with the concept of Nature. These were the eight mentioning habit or tradition and 11 of those mentioning risk. For the remaining 58, it seems Nature probably did play some role; although perhaps not exactly as we have postulated. If account is taken of the secondary factors mentioned by some of the farmers, it would appear that only nine farmers did not place emphasis on some aspect of Nature.

To what extent did the responses tabulated in Table 6 and those shown in Table 7 correspond? Our main concern is with those farmers marked by an asterisk in Table 6. It is they who came closest to the conception of the situation postulated by the model. Of these 31 farmers, only one was not among the 58 who mentioned a primary choice influencing factor compatible with our model.

Equivalently, included among the 46 farmers not marked by an asterisk in Table 6 were eighteen of the nineteen farmers who mentioned, as the primary influence on their feeder program choice, a factor apparently incompatible with the theoretical concept of Nature. There are thus 28 farmers whose response to the open-ended question on choice was compatible with the model while their formalized answers, as tabulated in Table 6, were not. The most reasonable explanation for this discrepancy is probably that these farmers did not answer the formal questions correctly in terms of their normal way of thinking about the problem. Certainly the majority of the farmers had not previously thought explicitly in terms of an opponent. This was indicated by many of the side comments on the formal questions. At the same time, it was obvious that many of the farmers thought and acted intuitively in terms of an opponent. In a sense, they were at war but did not wish to make a declaration of war.

Summarizing these comments on the data of Tables 6 and 7, it appears that at least 30 and perhaps as many as 58 of the 77 farmers had conceptions of an opponent in fair agreement with the model. A more definite statement would be desirable but, given the data, not warranted.

Discernment of states of Nature and associated payoffs

Nothing has been said, so far, of the payoffs involved in the model; nor of the postulated discrete states of Nature. The farmer's appreciation and use of these concepts is obviously dependent upon his thinking in terms akin to the model.

In attempting to assess farmer use of the payoff and state of Nature concepts, an oblique method of questioning was pursued. For each respondent, a game against Nature was constructed. This was done by way of question number IX:2 of Schedule B as shown in Appendix B. For this decision problem, each farmer's set of considered alternatives was taken as his available acts. Four broad states of Nature were delimited. These consisted of the four combinations possible from two types of weather - good and bad in terms of grain production - and two levels of aggregate activity on the part of other farmers with feeders - mainly short feeding or mainly long feeding. Prior informal questioning indicated that the inclusion of all the postulated components of Nature would make the problem too complicated. Hence the feeder raisers were specified as behaving in an "average or normal fashion". This may not sound very meaningful to the reader. However, it was sufficiently meaningful to the farmers to enable construction of the game against Nature. Only two farmers quibbled over the meaning of the words "average or normal".

For each of his available acts, the farmer was asked his expectation of cattle buying and selling prices under each of Nature's four possible states.

Two of the farmers found this formulation of the decision problem incomprehensible. Both of them were among the six farmers who are listed in Table 6 as having no formal conception of an opposition. The concepts involved assuredly meant nothing to them. The 75 farmers who did comprehend were asked if they normally considered their pre-purchase alternatives in some such way with payoffs varying according to the conditions that might prevail. Twenty-four said that they did. In each of these cases, however, further questioning indicated that the states of Nature involved in such considerations were very broad. Two of these farmers apparently considered four states of Nature, more or less in line with those postulated in the constructed game. One of these farmers considered two alternative acts, the other three. All of the other 22 farmers specified only two states of Nature. Nine of these pairs of states were based on the possible feed situation, 11 on the possible aggregative buying actions of other feeder fatteners, two on the possible cattle feeding programs of all other farmers and one on consumer demand for meat. Nineteen of these 24 farmers were included among the 31 marked with an asterisk in Table 6. All 24 were among the 58 farmers who mentioned as a primary influence on their choice a factor compatible with the theoretical formulation of Nature.

Fifty-three farmers apparently did not follow some specific conception of multiple states of Nature. It would seem that they made their deliberations in terms of a single state of Nature - perhaps with payoffs formulated as expected values or perhaps, as Tintner (80) has suggested, making their decision in terms of higher moments of the payoffs' probability distributions[1].

As a general assessment of the model, the farmers were asked whether they considered the constructed representation

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[1]By necessity, these probability distributions would be subjective.

of the pre-purchase decision problem to be a good, fair or poor representation of the problem. The responses were as follows:

good : 38

fair : 26

poor : 13

This rating is a subjective one. None the less, the figures indicate that the majority of the farmers considered the model reasonable in construction. Such a reaction is typical. As Luce and Raiffa (48, p. 292) note, once a normative mode of decision making has been pointed out to decision makers they will usually recognize it as such; often tending to consider the problem in such a manner in the future. It is interesting that all of the 31 farmers whose stated formal conception of an opposition approached that postulated by the model were included among the 64 who thought the constructed model either good or fair. In fact, 26 of them said it was good. Twelve of the 13 who said poor belonged to the group of 19 farmers who nominated as a primary influence on their choice a factor apparently incompatible with the model's conception of Nature.

The effect of outlook information

For a farmer considering feeder cattle as a possible enterprise, the crucial period for making plans and purchases is from July to December. During these months, outlook forecasts of feeder and fat cattle market conditions during the coming season are available. These predictions, emanating from official sources, are discussed and analyzed in many of the communication media used by farmers. Alternatively, by attending sales the farmer may make his own appraisal of the trend of events in determining what we have called Nature's strategy.

The fact that outlook information is available tends to overshadow the implication of our model that uncertainty exists. If the information were pertinent and accurate, and the forecasts made turned out to be correct, uncertainty would not prevail. However, such is not the case. One reason for this is a practical one. In principle, correct forecasts can be made. It is not necessarily true that predictions will be upset by reactions to the predictions. This has been shown by Grunberg and Modigliani (27) and Simon (75, pp. 79-87) and studied extensively by Theil (78, pp. 379-410). However, allowance for these reactions can only be made if a continuous function describing the reaction of those concerned to a published prediction or forecast is available. Such a function is not available with respect to outlook forecasts relevant to the feeder and fat cattle markets[1]. Evidence presented

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[1]Kutish, F. Department of Economics and Sociology, Iowa State College, Ames, Iowa. Outlook forecasts for cattle. Private communication. 1958.

below shows that farmers do react to outlook forecasts. Therefore, such forecasts, in so far as they are quantified rather than simply directional, can only be correct by coincidence. Moreover, even directional forecasts will be upset if reaction to the forecast is strong enough.

There is little evidence available as to the reaction of Mid-Western cattle feeders to outlook information and forecasts. Heer (32) in 1953 studied the directional accuracy of forecasts made in the Iowa Farm Outlook Letter (38) over the three previous years. This publication is a primary source of the outlook information that is made available to cattle feeders in Iowa. Heer's study indicated that 73 per cent of the predictions made therein about the beef cattle market were correct. However, utilizing Heer's data, it appears that of predictions made for cattle in the crucial pre-purchase period of the year from July to September inclusive, only 55 per cent were correct. For June to September inclusive, the figure was 62 per cent. It is noteworthy that the greatest reaction to published forecasts probably occurs during these months. Such reaction was probably a significant factor causing the percentage of successful predictions to decline during this planning and purchasing period. Moreover, it is likely that reactions to such forecasts have become stronger since 1953 - even to the extent that some farmers have become so subtle as to react to a forecast in the opposite direction to what would be expected. That this is so was evidenced by data collected in this study.

Before considering these data, an important feature of the published forecasts must be noted. It is that the majority of forecasts are not pertinent in terms of the decision problem within the feeder cattle enterprise. They do not, in general, consider a particular type of cattle versus another type. Among all the predictions studied by Heer (32, pp. 20-38), there is not one out of the 65 relevant to cattle that is couched in terms of specific types of cattle. Cattle are always referred to either as feeder cattle or fat cattle. Such information, if correct, is of use in deciding between the feeder cattle enterprise and other enterprises; for decisions within the feeder cattle enterprise it is practically useless. On these grounds alone it could be argued that available outlook information does not negate the implication of our model that absolute uncertainty prevails in the situation studied. The lack of specification in the forecasts, taken together with the data showing the lack of success in prediction during the feeder cattle planning and purchasing period, argues very strongly for the conclusion that absolute uncertainty does prevail.

So far as the descriptive value of the model is concerned, the important point is whether the farmers considered such information to be useful and whether they used it. To this end the farmers were asked if, prior to making their own decision, they actively sought information on the kinds of feeders already bought by other farmers or that they appeared interested in buying. Thirty-six of the farmers said they did, 41 saying no. These responses can be checked against the farmer's statement of his conception of the role of the other farmers with feeders as given in Table 6. Those who did seek such information should tend to consider other farmers with feeders as a group. The extent to which this was so is shown in Table 8.

Table 8. Correspondence between farmers' seeking of information and their conception of other farmers with feeders

Conception of other farmers with feeders	Number of farmers	
	Seeking information	Not seeking information
As a group	18	12
As individuals	13	16
Not mentioned	5	13
Total	36	41

Half of those who sought information considered other farmers with feeders as a group. This contrasts with the figure of approximately one third for those who did not seek information. As would be hoped, the majority of the respondents who did not mention other farmers with feeders as being important were among the group who did not seek information.

However, the correspondence between the two sets of data is not all that one would desire. Perhaps some of the farmers said they sought information in order to show themselves in a favorable light. Alternatively, some may not have understood the implications of their seeking information with regard to their conception of an opposition.

Outlook information was thought to be helpful in their pre-purchase planning by 29 of the farmers. Of the remainder, 21 thought it harmful and 27 thought it had no effect either way. All 29 of those who thought outlook information helpful were among the 36 who said they actively sought such information. That 48 of the 77 farmers did not consider the information to be helpful is further evidence that outlook information is of little use in combating the uncertainty surrounding the pre-purchase decision problem in the feeder enterprise. Indeed, two of the farmers who said the outlook predictions were helpful commented that this was because they then knew it would be better to do the opposite! In effect, they thought outlook information, taken at its face value, to be harmful. They must therefore be classed with the 21 farmers who said outlook information was harmful. These 21 farmers were asked why they thought this was so. The reason given by 13 of them was that too many farmers followed the prediction, causing it to be wrong. Four said that the forecasts were based on inaccurate information. The remaining four based their opinion on historical grounds: they had followed a forecast that was unsuccessful.

Summary

This chapter was aimed at assessing the descriptive value of the postulated normative model of the production decision problem facing an entrepreneur operating under free competition. To this end, data pertinent to the pre-purchase decision problem within the feeder cattle enterprise were examined. These data related to a population of 77 farmers.

Figure 1 summarizes the data by way of a tree diagram. Three types of branches may be distinguished in terms of agreement with the overall set of postulates of the model.

In Figure 1, the farmers are stratified at five levels. The first relates to the hypothesis that the farmers simplify the decision problem by selecting for consideration some small number of acts from all those that are available. As the tree shows, all the farmers did carry out this simplification. The second level of stratification is based on the farmers' statements of their conception of an opposition. For 31 of the farmers, this statement was in close agreement with the model although only three gave answers in exact agreement with the model. The third level of stratification hinges on the farmers responses to an open-ended question asking what was the primary factor influencing their choice between alterna-

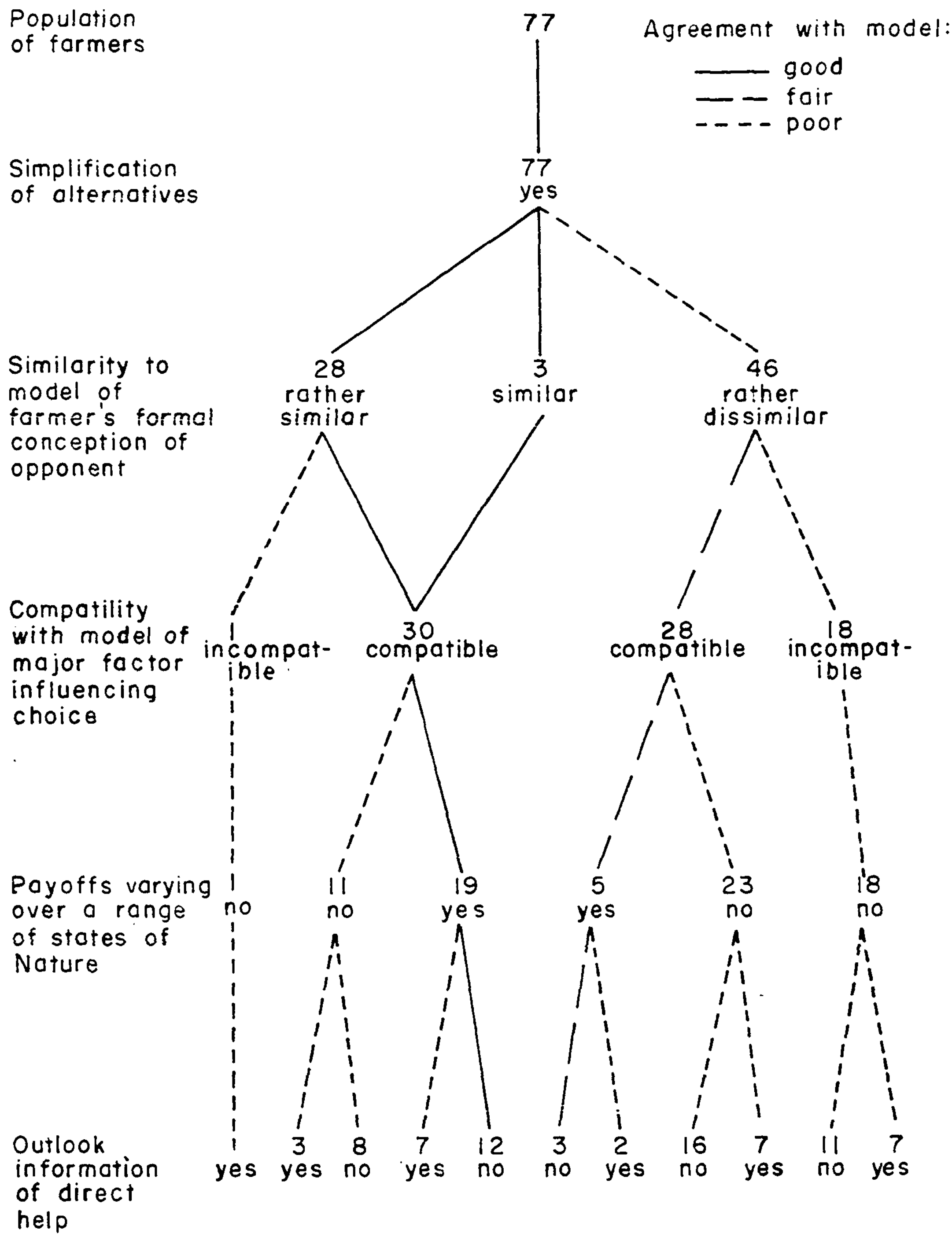

Figure 1. Classification of farmers in terms of agreement with major aspects of the postulated model

tive feeder cattle programs. These responses were classified on the basis of whether or not the specified factor was compatible with the model. The fourth level of stratification is based on the farmers' statements as to whether or not they considered their alternative acts in terms of payoffs varying according to the conditions that might prevail. Those who said yes were, at least in this regard, acting in agreement with the model. The last stratification level is based on the farmer's assessment of outlook information taken on its face value, as being helpful or not helpful. Those who thought such information of no direct help were in agreement with the model.

The tree shows that of the 77 farmers, 12 could be said fairly certainly to consider the decision problem in the fashion postulated by the model. For another three, the model was probably descriptively correct. Some of the remaining 62 farmers may have considered the problem in the manner postulated by the model but it is unlikely. In its entirety the model therefore has descriptive value for only a small proportion of the population examined.

None the less, a large proportion of the farmers did apparently behave in partial agreement with the model. Thus all 77 farmers considered a simplified set of alternative acts; 58 specified as the primary factor influencing their choice a factor compatible with the model; 24 made allowances for payoff variations over various possible states of Nature;

and 50, in so far as they thought outlook information to be of no direct help, probably considered the decision problem as one involving a high degree of uncertainty.

VIII. ASSESSMENT OF THE THEORIES OF CHOICE

A number of theories of choice applicable to decision making under absolute uncertainty were presented in Chapter III. The mechanics of their use was illustrated by an example in Chapter IV. The present chapter is devoted to an empirical appraisal of these theories. The source and collection of the data to be used has been discussed in Chapter VI; it suffices to point out here that the data refer to the same population of 77 farmers considered in our appraisal of the model.

In assessing the role played by the theories, we attempt to answer the five questions listed below. The answers given to these questions will not apply to all decision makers under absolute uncertainty[1]. Strictly speaking, the answers relate only to the 77 individuals studied. We recognize this fact. However, the data will also be analyzed statistically as if the 77 farmers were a random sample from the super-population of all Corn Belt owner-operators between 30 and 50 years of age who had fed an average of at least 25 feeder cattle in

[1]Absolute uncertainty prevails when the decision maker has no objective knowledge of the likelihood of occurrence of the possible outcomes of his decision. He knows only what outcomes may occur.

each of the three feeding seasons prior to the survey[1]. Throughout the text whenever we refer to the survey panel as a random sample, we will always mean a random sample from this super-population. In this manner, the presentation is made a little less cumbersome. The assumption of randomness relative to the super-population is an extremely strong assumption. We have no evidence to support it, the data necessary to test the reliability of the assumption being unavailable. In consequence, we report the statistical tests based on this assumption with diffidence. Perhaps they will be of interest to the reader despite their inadequacies.

The questions considered in this chapter are as follows, the first three being concerned with the descriptive value of the theories and the last two with their possible normative role.

1. To what extent do the theories have descriptive value? In other words, do the farmers tend to make decisions under absolute uncertainty by analyses of the situation similar to those postulated by the theories?
2. How stable is the decision maker's approach to deci-

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[1] F tests based on analysis of variance and Chi-square tests will be the principal statistical procedures used. In using analysis of variance to make tests of significance, it will be assumed that the data fulfill the necessary assumptions, viz. that the various fixed effects and the error are additive and that the errors are noncorrelated and normally distributed.

sion making as the setting of the decision problem varies?

3. So far as the theories are descriptively true, what characteristics of a decision maker's background tend to be associated with the selection of a particular approach to the decision problem?
4. For those theories advanced as normative decision criteria, what value might they have in reducing *ex ante* resource misallocation? Equivalently, for the decision problems studied, do salient discrepancies exist between the farmers' solutions and the normative solutions?
5. Are there noteworthy differences between the various normative decision criteria in the degree to which they reduce *ex ante* resource misallocation in the situations studied?

Answers to these questions, so far as they can be given, will be based on the farmers' solutions of a number of decision problems under absolute uncertainty. These problems were of two types, some being completely hypothetical and some representing a practical problem within the feeder cattle enterprise. To simplify the presentation we will first consider these two sets of problems separately, drawing the analyses together later. We begin by considering the hypothetical decision problems.

Description of the Hypothetical Decision Problems

These problems were based on the payoff matrix used to exemplify the theories in Chapter IV. For convenience, this matrix is reproduced below.

Decision maker's alternatives	States of Nature S_1	S_2	S_3	S_4
A_1	2,500	3,500	0	1,500
A_2	1,500	2,000	500	1,000
A_3	0	6,000	0	0
A_4	1,500	4,500	0	0

In posing the hypothetical problems to the farmers, the alternative acts A_1, A_2, A_3 and A_4 were described simply as four possible annual investments; each requiring the same amount of capital. The payoffs shown opposite each act were specified as the possible dollar net returns that might accrue over the investment year if that act were chosen. It was pointed out that for a given investment choice, the likelihood of receiving any particular payoff relevant to that choice was completely unknown; the decision maker could only be sure that he would receive one of the payoffs listed opposite whichever act he selected.

This basic problem was posed in four "once only" contexts. Two of these specified that the alternative selected was to be the only income source; the other two that a sure annual income of \$3,000 additional to that derived from the selected act was also available. For each of these income situations the farmer was asked which act he would choose when the selected investment, firstly, could only be made once and, secondly, had to be made in each of 20 consecutive years. It was stipulated that Nature's strategy might vary from year to year over these 20 years.

The farmers were asked to treat each problem as if it were a real-life decision that had to be made under their current circumstances. No attempt was made to specify the available acts as real-world alternatives. However, the net income figures used are not unrealistic compared to those commonly found throughout the survey area[1]. For each solution nominated, the raison d'être for that specific choice was also requested.

All the farmers were owner-operators with considerable resources at their disposal. Also, none of the alternative acts could lead to absolute losses. It is therefore reasonable to regard the one year setting of the problem as having only short-run effects; the 20 year setting being considered as having long-run repercussions on the decision maker. Thus

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[1]Howell, H. B. Department of Economics and Sociology, Iowa State College, Ames, Iowa. Net farm incomes in Marshall County, Iowa. Private communication. 1957.

the four decision problems can be characterized as follows:

(a) short-run with no sure income;

(b) short-run with sure income;

(c) long-run with no sure income;

(d) long-run with sure income.

Descriptive Role of the Theories of Choice: Hypothetical Decision Problems

The frequencies with which each of the alternatives were chosen in each setting of the problem by the 77 farmers are listed in Table 9. For convenience, the theories of choice compatible with the selection of each alternative are also noted in the table. A_1 and A_2 were the acts most frequently selected. With no sure income available, the majority of farmers chose A_2. With an additional sure income, the majority chose A_1. Only when an additional sure income was available did a significant proportion of the respondents choose A_3 or A_4.

Had the farmers made their selections in a random manner, a distribution pattern with approximately 20 selecting each act would be expected. In no case do the listed distributions approach such a pattern. Moreover, as Table 9 shows, there are quite distinct differences between the frequency patterns for each setting of the decision problem. *Ipso facto*, it is concluded that the farmers made their choices in an active

Table 9. Decision theories compatible with the selection of each alternative and the number of farmers selecting each alternative in each hypothetical decision problem

Alternative selected	Compatible decision theories[a]	Setting of decision problem			
		No sure income		Additional sure income	
		Short-run	Long-run	Short-run	Long-run
		no.	no.	no.	no.
A_1	Laplace;	22[b]	32[b]	41[c]	44[c]
A_2	Wald; Hurwicz[d]; Simon[e]; Shackle;	52[c]	41[c]	16	13
A_3	Hurwicz[f]; Shackle;	2	2	13	6
A_4	Savage;	1	2	7[b]	14[b]
	Total	77	77	77	77

[a]Simon's theory with a zero aspiration level is compatible with each alternative.

[b]Including one of the two farmers with extremely large farms.

[c]Including one of the two farmers with extremely large farms.

[d]With $\beta \geqslant 8/9$.

[e]With an aspiration level greater than zero.

[f]With $\beta \leqslant 8/9$.

way and that credence may be given to their explanations of these choices. Assuming the 77 farmers to be a random sample, Chi-square "goodness of fit" tests strongly support the hypothesis that the farmers' selections were purposive[1]. Relative to an equal distribution of frequencies throughout the cells of Table 9, the value of Chi-square for each problem setting is as follows:

short-run with no sure income : 74.3;
short-run with sure income: 34.9;
long-run with no sure income: 32.8;
long-run with sure income: 44.4.

A Chi-square test for independence between the setting of the decision problem and the alternatives chosen, regarding the data matrix of Table 9 as a contingency table, also led to rejection of the hypothesis that the choices made were independent of the problem setting. The value of Chi-square was 75.2 with no pooling of the data and 67.4 when the frequencies for A_3 and A_4 were pooled.

<u>Decision procedures followed</u>

In all cases in which A_1 was chosen, the respondents gave

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[1]In making these tests, the frequencies for A_1, A_3 and A_4 were pooled in each of the "no other income" settings of the problem, as suggested by Snedecor (76, p. 30) for cases where some classes have frequencies of less than five.

as their reason that it had the highest average payoff or that its row total was the largest. Selection of A_1 was therefore always based on the Laplace criterion. It was not based on the use of Simon's theory with a zero aspiration level; this was quite evident during the collection of the data. Selection of A_1 was always preceded by some numerical calculations on the part of the respondent, either of row totals or averages. Numerical calculations by the respondent never led to any choice other than that of A_1.

All farmers selecting A_2 indicated that they did so because it guaranteed a minimum return of $500 under all possible states of Nature. Their reasoning is in agreement with the Wald criterion, the Hurwicz criterion with a zero degree of optimism, Simon's theory and the special case of Shackle's theory when it is equivalent to the Wald criterion. We have already noted that the Hurwicz criterion with a zero level of optimism is equivalent to the Wald criterion. Given the respondents' reasoning, it seems most probable that the selection of A_2 was generally based on a Wald maximin approach or the use of Simon's theory with a non-zero aspiration level, rather than on the special cases of the Shackle and Hurwicz theories. Moreover, in situations where the decision maker's aspiration level exceeds or equals the maximum minimum payoff, Simon's theory is equivalent to the Wald criterion. There is thus only a small chance of error in attributing the selection of A_2 to a Wald criterion type of approach. Certainly it is the approach most implicit in the farmers' raison d'etre.

All explanations given by the farmers for the selection of A_3 emphasized a preference for gambling. In choosing A_3, the respondents recognized its riskiness relative to the other alternatives but were attracted by the possibility of receiving the maximum possible payoff of \$6,000. Such behavior rules out the Simon theory as a basis for selection of A_3. A gambling motivation is, however, quite compatible with a Shackle or a Hurwicz type of approach. Perhaps the most that can be deduced from the reasons given for the selection of A_3 is that its choice was probably based on some Hurwicz type criterion, the general form of which, as given by Radner and Marschak (64, p. 62), subsumes the Shackle approach when absolute uncertainty prevails.

A gambling motivation was generally given for the choice of A_4; many of the farmers suggesting that this investment alternative was chosen as a compromise between the relative "safeness" of A_1 or A_2 and the "riskiness" of A_3. Such reasoning is suggestive of the Savage regret approach although no farmer came close to giving an explicit statement of this criterion as the basis for his selection of A_4.

Overall, it appears that only the Laplace and the Wald criteria have widespread descriptive value in explaining the farmers' choice. Conversely, Shackle's claim to have formulated a general explanation of decision making must be dismissed. In choosing A_1, a large proportion of the respondents made a choice incompatible with Shackle's hypothesis.

Stability of choice

Nothing has been said of the shifts in choice that occurred as the setting of the hypothetical decision problem varied. Inspection of Table 9 shows that many changes in choice occurred; otherwise each alternative would have been selected the same number of times in each of the four settings of the decision problem. Only a third of the farmers did not alter their choice as the problem's context varied. One farmer always chose A_4, one always A_3, 11 always A_2 and 13 always A_1. It is certain that the shifts in choice that occurred are a function of the particular payoffs and problem settings specified in the hypothetical problems. In consequence, the changes in choice will not be discussed in full detail. Only the general implications of the data will be considered. Of these, the most important is the fact that two-thirds of the respondents varied their decision making approach as the context of the decision problem altered. It would be interesting to study the pattern of these changes in approach over a range of assured incomes and time influences. This is not possible here. Our data are too limited.

Of the changes in choice that occurred, the majority related to the income setting of the problem and not the length of time over which the decision would be influential. To some extent, this is revealed by inspection of Table 9. It is shown far more clearly by the data of Tables 10 and 11.

Table 10 relates to the time setting of the hypothetical decision problem. In it, no account is taken of the income

Table 10. Frequency of occurrence of pairs of choices among the alternatives A_1, A_2, A_3 and A_4 relative to the time settings of the hypothetical decision problems; and frequency with which each alternative was selected in each time setting

Choice in short-run setting	Choice in long-run setting A_1	A_2	A_3	A_4	Total frequency
	no.	no.	no.	no.	no.
A_1	57	3	1	2	63
A_2	17	51	0	0	68
A_3	2	0	7	6	15
A_4	0	0	0	8	8
Total frequency	76	54	8	16	154

setting of the decision problem. The table entries were derived by adding together the corresponding frequencies for each choice pair A_iA_j ($i = 1,2,3,4$; $j = 1,2,3,4$) in the two "no sure income" settings of the problem and in the two "additional sure income" settings of the problem; A_i and A_j referring to the choices made by each respondent in the short-run

Table 11. Frequency of occurrence of pairs of choices among the alternatives A_1, A_2, A_3 and A_4 relative to the income settings of the hypothetical decision problems; and frequency with which each alternative was selected in each income setting

Choice in no sure income setting	Choice in additional sure income setting				Total frequency
	A_1	A_2	A_3	A_4	
	no.	no.	no.	no.	no.
A_1	32	0	10	12	54
A_2	53	29	5	6	93
A_3	0	0	4	0	4
A_4	0	0	0	3	3
Total frequency	85	29	19	21	154

and long-run contexts of the problem, respectively. Since each farmer was asked to make two short-run and two long-run decisions, each respondent is recorded twice in Table 10. Equivalently, the table relates to twice 77 or 154 choice pairs. Entries on the main diagonal of the table's "A_iA_j matrix" indicate the number of times out of 154 that the choice pair A_iA_j (i=j) occurred. Such pairs constitute 80 per cent of the total number of choice pairs. In other words, 80 per cent of the solutions given by the farmers relevant to the time setting of the problem show no change in choice (or change in the decision making approach) as the time setting of the problem varied. Assuming the survey farmers to be a random sample, the 95 per cent confidence interval for the percentage of choice pairs of the type A_iA_j (i=j) is from 71 to 87 per cent[1].

The frequencies of choice pairs of the type A_iA_j ($i \neq j$) are shown by the entries off the main diagonal of the "A_iA_j matrix" of Table 10. Each such pair represents a shift in choice by a respondent between the short-run and long-run setting of the problem. Thirty-one such shifts in choice occurred; of these, 17 were away from A_2 into A_1 as the time influence of the decision became greater. Remembering that the _raisons_ _d'être_ for selecting A_2 generally suggested use of the Wald criterion while those for A_1 corresponded to the Laplace criterion, it appears that the majority of the shifts in choice occasioned by the extension of the decision's time influence related to a change from a Wald to a Laplace approach. The converse change, indicated by the pair A_1A_2, occurred three times. The choice pair A_3A_4 occurred six times, indicating in these cases a change from a conservative to a less conservative approach as the time influence of the decision lengthened. Overall, despite the conflicting tendencies noted, the data indicate that the farmers were least conservative in their long-run decisions; remembering, however, that the majority of the choice pairs indicate no change in the

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[1]Based on the assumption that the number of such choice pairs follows a binomial distribution (76, pp. 2-6).

respondents' decision making approach as the time setting of the problem varied.

Except that it relates to the income context of the hypothetical decision problems and takes no account of their time setting, Table 11 is similar in construction to Table 10. Mechanically, it may be read in the same fashion as Table 10. Such perusal indicates that only 68 out of 154, or 44 per cent, of the solutions given by the farmers relevant to the income setting of the problem show no change in choice (or change in the decision making approach) as the income setting of the decision problem varied. Again assuming the survey panel to be a random sample, the 95 per cent confidence interval for this estimate of 44 per cent is from 34 to 54 per cent. The figure of 44 per cent contrasts markedly with the corresponding figure of 80 per cent relative to the time setting of the problem. Obviously, within the range of time and income settings specified, the respondent's decision making approach was generally far more responsive to variations in the income setting of the problem than to variations in the time setting. Inspection of Table 11 reveals that altogether there were 86 shifts in choice between the two income contexts of the problem; 53 of these changes were away from A_2 into A_1, implying a shift from a Wald to a Laplace approach, as the income uncertainty associated with the decision decreased. Indeed, perusal of the off-diagonal entries of Table 11 shows that every change in choice was either away from A_2 into A_1, A_3 or A_4, or from A_1 into A_3 or A_4 as income uncertainty decreased. Since the raisons d'être given for selection of A_3 or A_4 invariably involved a gambling motivation, it is apparent that every shift in choice denoted the adoption of a less conservative decision making approach as the income uncertainty inherent in the problem's context declined. Moreover, comparison of the choice frequencies given in Table 9 for similar time settings of the problem reveals that a majority of the respondents changed their decision making approach as the income setting of the problem varied. This is in contrast with the situation relative to variations in the time influence context of the problem. As Table 9 also shows, only a minority of the respondents altered their approach to the problem as its time influence varied.

Comparing the solutions for the long-run and short-run problems with no sure income available, as listed in Table 9, little difference in popularity between A_3 and A_4 is evident. Indeed, neither of these acts were very popular; apparently, with no additional sure income available, only a few of the farmers were prepared to gamble. However, with an additional sure income of \$3,000 available, both A_3 and A_4 became far more popular. Also, inspection of Table 9 shows that a distinct difference in popularity between A_3 and A_4 developed as the period of influence of the decision varied: in the short-run setting A_3 was by far the most popular of the two; in the long-run context, the position was reversed[1]. Since A_4 is intuitively a safer investment than A_3, it appears that most of those farmers who "gambled" in the sure income setting preferred to take greater risks in their short-run decisions than in their long-run decisions. This contrasts with the behavior of those who switched from a Wald type of approach to the Laplace algorithm as the time influence of the decision became greater. The latter tended to take greater risks in their long-run decisions. Numerically, the former group were more important.

<u>Associations between patterns of choice and selected characteristics of the respondents</u>

The respondents were asked to solve the hypothetical decision problems in terms of their current circumstances. Assuming that they did, we now consider these solutions against the respondents' backgrounds; attempting to perceive what associations exist between the patterns of choice over the four problems posed and some basic attributes of the respondents. In doing this, we will exclude those two respondents who operated extremely large firms relative to the other 75 members of the population. While the age, education and num-

[1]Assuming the population to be a random sample, the (adjusted) Chi-square test value for this difference in popularity is 3.6. This value is significant at the six per cent level.

ber of dependents of these two farmers were not atypical, their financial attributes and the characteristics of their farm operation were very different. To include these two farmers in an analysis based on averages would accord them too much influence[1].

Table 12 lists the means of some characteristics of those farmers following each of the patterns of choice shown at the top of the table. Four choice patterns are delimited; intuitively, they are the most meaningful of all those that might have been listed. For both A_1 and A_2 there was a noteworthy number of farmers who chose this single act in each of the four settings of the hypothetical decision problem. These farmers are grouped separately in the table under the headings of "Always A_1" and "Always A_2". The 13 farmers who always selected A_1 used the Laplace criterion consistently. It is most likely that the 11 who always chose A_2 were following an approach of the Wald type. The remaining farmers are classified into two groups: those who changed their choice as the setting of the problem varied but always selected either A_1 or A_2; and those who selected either A_3 or A_4 at least once as a solution for one of the four problems posed. A_3 and A_4 are grouped together because, intuitively, they are the least safe of the alternative acts. Their selection,

[1]The choices made by these two farmers are indicated by footnotes b and c of Table 9.

Table 12. Average of selected characteristics of those farmers within each decision pattern group[a]

Characteristic	Unit	Decision pattern over the four hypothetical decision problems				Overall average
		Always A_2 (11 farmers)	Either A_1 or A_2 (22 farmers)	Always A_1 (13 farmers)	Sometimes A_3 or A_4 (29 farmers)	(75 farmers)
Age	year	45.2	40.2	42.4	42.1	42.1
Formal education	year	10.9	11.1	12.0	11.8	11.5
Dependents	no.	2.8	3.6	3.4	3.9	3.6
Total capital invested	\$1,000	91.0	121.2	127.5	96.8	108.5
Net worth	\$1,000	84.6	107.2	104.6	82.3	93.9
Equity	per cent	93.0	88.4	82.0	85.0	86.5
Feeder cattle purchased[b]	no.	77.7	115.6	121.9	115.5	111.1
Calves	per cent[c]	62.2	44.7	59.6	39.1	47.1
Yearlings	per cent[c]	37.8	54.8	34.4	49.6	47.1
Two-year olds	per cent[c]	0.0	0.5	6.0	11.3	5.8

[a]The two farmers with extremely large farms are excluded.

[b]Cattle purchased during the period July 1, 1956 to June 30, 1957.

[c]Per cent of number of feeder cattle purchased.

given the availability of A_1 or A_2, implies a tendency to gamble or at least to take risks. Conversely, A_1 and A_2 are, relative to A_3 and A_4, conservative alternatives. In Table 12, these four decision patterns are tabled from left to right in their intuitive order of decreasing conservativeness. The far right column of the table lists the mean of each considered attribute for the overall group of 75 farmers.

Assuming the survey panel to be a random sample, F tests based on analysis of variance (76, pp. 268-269) indicate that no significant differences[1] exist among the means listed in Table 12 relative to each characteristic. None the less, the associations between the decision making patterns and the decision maker's characteristics as revealed in Table 12, are significant in terms of the population of 77 farmers. Moreover, as the following discussion shows, the data of Table 12 tend to follow what might be termed an explainable - or at least not unexpected - pattern.

Age Those farmers who always selected A_2 tended to be the older members of the population. It seems reasonable that these older respondents should use a Wald type of approach. They probably place more emphasis on maintaining their current situation as a base for their retirement rather than on bettering their current status. The younger members of the group generally chose either A_1 or A_2, switching be-

[1]At the 10 per cent level of significance.

tween the Laplace and Wald approaches as the context of the decision problem varied.

<u>Education</u> On the average, those respondents who chose A_2 had the smallest number of years of formal education. To some extent, this may be correlated with the fact that these farmers tended to be the elder ones; their opportunities to obtain education may not have been as great as those available to younger members of the population. Those who used the Laplace criterion, choosing A_1, had the most education.

<u>Dependents</u> Perhaps unexpectedly, those who always chose A_2 had the smallest number of dependents. This may be because these farmers were, in the main, the older ones whose children, in consequence, were no longer classed as dependents. Introspectively, we would have thought conservative choices to be associated with a larger than average number of dependents; especially among farmers, for their business and family interests are so closely associated. However, those respondents with a more than average number of dependents tended to choose the more risky but possibly more remunerative alternatives, A_3 and A_4, at least once. It may be that a larger number of dependents leads to the taking of greater risks, on the average, because of greater pressure on available income and the relatively larger income necessary for goal satisfaction.

<u>Total capital invested</u> Quite large differences existed among the four groups in terms of their capital investment. Above average investment tended to be associated with consistent selection of A_1 or of either A_1 or A_2. On the other hand, those choosing A_2 had the smallest capital investment. Small capital investment, relative to the average investment of the overall group, was also associated with selection of A_3 or A_4. It would be especially interesting to know what, if any, causal relationships predominate among these particular associations.

<u>Net worth</u> Those farmers with a smaller than average net worth tended to follow either the least conservative choice pattern, sometimes selecting A_3 or A_4, or else the most conservative pattern, always choosing A_2. Such contrasing decisions suggest that the decision maker's inherent psychological makeup may be the dominant influence affecting his choice.

<u>Equity</u> <u>Ceteris paribus</u>, the lower an entrepreneur's equity ratio, the greater the risk he is taking. To a degree, therefore, an entrepreneur's equity ratio is an indication of his willingness to take risks. This is borne out by the equity data of Table 12. Those respondents with a higher than average percentage equity either always chose A_2 or either A_1 or A_2. As previously mentioned, these are the two most conservative choice patterns among the four patterns de-

limited. Indeed, those choosing A_2 - which corresponds to a Wald type of approach to the decision problem - had a very high percentage equity on the average. Conversely, those who used the Laplace approach or tended to gamble by sometimes choosing either A_3 or A_4 had relatively low equity ratios.

Feeder cattle purchased   Compared to other enterprises possible on Mid-West farms, the feeder cattle enterprise is very risky (7, p. 327). Hence, to some extent, the size of a farmer's feeder enterprise is an indication of his tendency to take risks. However, the total number of cattle or any other unweighted aggregate index is only a rough indication of the risk taken. Such measures do not take account of the differences in risk between the various age types of cattle; differences that are quite substantial. Least risky are calves while two-year olds are extremely risky. Yearlings have an intermediate level of associated risk (49, pp. 3-5). Against this background, we now consider the cattle data listed in Table 12.

As expected, those farmers who used a Wald type of approach, always choosing A_2, tended to have smaller feeder cattle enterprises. Moreover, their feeder operation contained the greatest proportion of calves of any of the groups listed and the smallest proportion of two-year olds. Conversely, those who tended to gamble by sometimes selecting A_3 or A_4 had the largest proportion of two-year olds and the smallest proportion of calves. Since two-year olds are the most risky type of cattle to fatten, it is not surprising that the importance of two-year olds increases across the table as the conservatism of the decision pattern decreases.

Beyond listing in Table 12 the number of respondents within each group, nothing has been said so far of the relative importance of the four decision pattern groups. If the panel farmers are regarded as a random sample, the 95 per cent confidence interval[1] for the percentage of farmers within each group is as follows, the groups being listed as in Table 12:

Always A_1	:	9 to 24 per cent;
Either A_1 or A_2	:	20 to 39 per cent;
Always A_1	:	10 to 26 per cent;
Sometimes A_3 or A_4	:	29 to 49 per cent.

Thus it appears that for decision problems under absolute uncertainty falling within the range of time and income settings studied here, repeated samplings would estimate that perhaps as few as 51 per cent or as many as 71 per cent of the decision makers within the super-population might approach such problems only in the fashions postulated by Wald and Laplace[2].

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[1]Based on the assumption that the number of farmers in each group follows a binomial distribution (76, pp. 2-6).

[2]There is one chance in 20 that the relevant percentage would lie outside the specified range.

From an economic viewpoint, a more interesting measure of the relative importance of the decision pattern groups is their role in terms of production; that is, _vis à vis_ the market. For our purposes, a satisfactory index of this is the relative weight of feeder beef purchased and fat beef sold by each group. Such figures are listed in Table 13 for the

Table 13. Percentage of feeder beef bought and of fat beef sold, in 1956-57 by the survey panel, handled by each decision pattern group

Decision pattern group	Per cent of all feeder beef bought	Per cent of all feeder beef sold
Always A_2	9.3	10.0
Either A_1 or A_2	30.1	30.4
Always A_1	17.9	18.8
Sometimes A_3 or A_4	42.7	40.8

1956-57 season. It is noteworthy that those who changed their decision making approach, as the setting of the hypothetical decision problem varied, handled nearly three quarters of all the beef fed.

We now sum up the data of Tables 12 and 13.

Most distinctive, but least important, were those farmers who always chose A_2. In making this selection they apparently used a Wald criterion approach. On the average, they were the oldest and least educated members of the population. They had the highest average equity ratio and the smallest total capital investment. Also, they tended to have the smallest feeder enterprises and, within this enterprise, to feed the highest proportion of calves.

Those respondents who gambled by sometimes selecting A_3 or A_4, probably on the basis of some Hurwicz or Savage type of approach, were characterized by a relatively high educational level, a relatively low capital investment, the smallest equity ratio and the largest number of dependents of any decision pattern group. Their feeder enterprises tended to be larger than average; and to have the highest proportion of two-year olds and the smallest proportion of calves among the four groups studied. Of all, they were the most important group.

The farmers who consistently used the Laplace criterion, always choosing A_1, generally had the most years of formal education, a relatively high net worth and a low equity ratio.

The data suggest that those respondents who varied between a Laplace and a Wald type of approach were not simply a "cross" of those who used only a Wald approach or only a Laplace approach. Compared with the latter two groups, farmers choosing either A_1 or A_2 tended to be wealthier, younger and to have more dependents. Also, their feeder enterprise consisted mainly of yearlings with a lower proportion of calves than was found in either of the groups based on consistent use of only the Laplace or only a Wald type of approach.

It would be interesting to know what, if any, causal relations exist among the associations drawn out above. From our data we can say nothing in this regard. Nor will we digress to explore the implications of the above material for analyses of feeder beef demand and fat beef supply.

Normative Role of the Theories of Choice: Hypothetical Decision Problems

No normative implications of real-world import can be drawn from analysis of the farmers' solutions of the hypothetical problems. The idealized arrangement of the payoff matrices precludes the discernment of irrational choices. Also, the problems have no specific real-world connotation. We therefore pass directly to a consideration of the practical problems and the respondents' reactions to them.

Description of the Practical Decision Problems

These problems were constructed from data supplied by the farmers[1]. They relate to pre-purchase planning within the feeder cattle enterprise. Each farmer's set of considered feeder programs, as discussed in Chapter VI, were taken as

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[1]The question used was number IX:2 of Schedule B as shown in Appendix B.

his alternative acts[1]. For each of these possible programs, the farmer was asked to give his expectation of the most probable buying and selling price of cattle under four possible states of Nature[2]. Two farmers could not do this. Formulation of the decision problem in such terms was beyond them. In consequence, the major part of the analysis of the practical problems refers to 75 respondents.

The specified states of Nature were the four combinations possible between two mutually exclusive weather possibilities and two mutually exclusive aggregative fattening policies on the part of all other farmers with a feeder cattle enterprise. The feeder raiser group was specified as behaving in "average or normal fashion". The reason for this simplification is discussed on pages 84 and 85 above. Admittedly, each respondent may have had a different conception of average behavior by the feeder raiser group. However, a lack of absolute uniformity in the respondents' conception of the feeder raisers' role does not vitiate the analysis. Our primary interest is in the individual farmer's solutions of the problems posed; not in any aggregation of these solutions.

Weather was specified in terms of the magnitude of the

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[1]The alternatives considered by each farmer are listed in Appendix C.

[2]These expected buying and selling prices are tabulated in Appendix D.

national corn crop. The two alternatives were a large national corn crop leading to an average corn price of $1.10 per bushel through the fattening season or a small corn crop giving rise to an average price of $1.30 per bushel. By using this mode of expression, the possible effects of the weather were defined in a manner meaningful to the farmers. The alternatives open to all other cattle feeders were taken as their planning to produce mainly short-fed cattle to be sold from March to June or mainly long-fed cattle to be sold from June to September. The four combinations among these alternatives will be designated as follows:

S_1: good cropping weather, marketings mainly March to June;

S_2: good cropping weather, marketings mainly June to September;

S_3: poor cropping weather, marketings mainly March to June;

S_4: poor cropping weather, marketings mainly June to September.

Having obtained the farmer's price expectations for each of his acts under each state of Nature, he was immediately asked which alternative(s) he would select. The number of cattle to be fed under each program was also requested. From these data, the proportion of the farmer's feeder enterprise resources that would be devoted to each alternative was calculated. As in the real-world situation, the respondent was allowed to select the null alternative of having no feeder cattle if he desired. The problem was posed under the following three circumstances: first, with either good or poor weather possible; second, with good weather certain; third, with poor weather assured. For each of these problems it was specified that absolute uncertainty prevailed over Nature's possible states.

Normative payoff matrices were constructed from the price expectation and cattle feeding data supplied by the respondents[1]. In these matrices, the payoff elements were expressed as the expected percentage net return on each act, allowance being made for the length of the investment. Constant returns to scale were presumed to prevail in each alternative[2]. Under this assumption, the payoff elements are comparable. Assuming profit maximization, as our model does, a basis of preference exists between individual payoffs. Theoretical solutions to the practical decision problems were obtained by applying the theoretical procedures, as illustrated in Chapter IV, to the normative payoff matrices[3].

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[1]The construction of the payoff matrices is explained in Appendices E and F. The matrices are listed in Appendix G.

[2]No evidence could be found to vitiate this assumption.

[3]The theoretical solutions are tabled in Appendix H.

We may now examine the farmers' solutions[1] of these practical decision problems; studying them in relation to the questions raised at the beginning of this chapter. As before, we begin by considering the descriptive role of the theories of choice.

Descriptive Role of the Theories of Choice: Practical Decision Problems

In terms of the practical decision problems, we can only consider the descriptive role of the Laplace equiprobability, Wald maximin and Savage regret theories of decision making under absolute uncertainty. The theories of Hurwicz, Simon and Shackle cannot be appraised. Why? Because the respondents' pessimism-optimism indices, aspiration levels and gambling indifference maps are unknown. Nor will the Wald maximin and Savage regret criteria be considered with only pure strategies permitted. Since mixed strategies are feasible in the practical problems, it would be irrational to consider the Wald and Savage procedures only in terms of pure strategies. Thus, in referring to these criteria in relation to the practical problems, we will always imply their use with mixed strategies allowed.

Relevant to our analysis, the theoretical solutions of the practical problems can be divided into two main classes.

[1]The farmers' solutions are tabled in Appendix H.

If the payoff matrix contains a dominant row, all three theories - Laplace, Wald and Savage - select as optimal the act corresponding to that row; all three answers to the problem are then identical. Such occurrences constitute the first grouping of the theoretical solutions. When the payoff matrix does not contain a dominant row, the theories will not suggest identical solutions. Such occurrences constitute the second class of solutions. The relative importance of these two groupings of the solutions is shown in Table 14 for each problem setting.

Table 14. Classification of theoretical solutions to the practical decision problems

Problem setting	Number of problems in which the Laplace, Wald and Savage solutions were:	
	Identical	Not identical
Good weather certain	60[a]	15
Poor weather certain	66	9
Either good or poor weather	52[a]	23

[a]Including one problem whose solutions, for all practical purposes, were identical.

Thus, of the 225 problems constructed, 178 contained a dominant alternative which was automatically selected by each of the theoretical decision procedures. That so many dominant acts existed is partly due to the small number of alternatives present in each problem. It also reflects the feelings of those respondents who did not attach strong differential effects to some or all of Nature's possible states.

Assuming the survey panel to be a random sample, a Chi-square contingency test value of 8.0 for the data of Table 14 indicates that there is less than one chance out of a 100 that the occurrence of identical solutions is not independent of the setting of the practical decision problems. Moreover, as the discussion below outlines, a reasonable explanation can be given for the pattern of the data in terms of our theoretical model.

Dominant alternatives tended to occur most frequently when poor weather was certain. This is possibly a reflection of the fact that with poor weather assured, fewer cattle would be fed and fewer farmers would feed cattle. Under such circumstances there would be fewer aggregative maneuvers possible by those other farmers fattening feeder cattle; a phenomenon most likely leading to a smaller range of possible variation in fat cattle prices and, concomitantly, a greater chance that a dominant alternative might exist. Conversely, with either good or poor weather possible, it might be expected that there would be least chance of a dominant alternative occurring. As the above figures show, dominant alternatives were least frequent when the weather was not specified.

We will first examine the farmers' solutions for those problems containing a dominant alternative.

<u>All theoretical solutions identical</u>

Table 15 gives a qualitative classification of the farmers' solutions for those 178 problems with a dominant alternative. The classification is in terms of the agreement between the farmer and theoretical solutions. As previously mentioned, the theoretical solutions were obtained by applying the relevant decision criteria to the normative payoff matrix of each problem. For each problem setting, the total number of farmers within each solution classification is shown at the bottom of Table 15. These totals are also given as a percentage of the total number of problems in each setting. Comparison of these percentages within each qualitative grouping indicates that little variation existed between problem settings. The reason for this is easily given: in most cases, a farmer's solutions for all three problem settings fell in the same qualitative class.

Averaged over each problem setting, 41 per cent of the farmers' solutions coincided exactly with the theoretical solution; in addition, 46 per cent of the farmers' solutions overlapped the theoretical solution. These were cases where the farmer selected a mixed strategy that included the optimal act as a component. For only 13 per cent of the problems were the farmer and theoretical solutions disjunct. Obviously, the respondents tended to select, at least as a part of their program, the alternative suggested by the theoretical pro-

Table 15. Correspondence between farmer and theoretical solutions to the practical decision problems in those cases where all theoretical solutions were identical

Number of alternatives considered	Number of cases in which the farmer and theoretical solutions were identical			Number of cases in which the farmer's solution overlapped the theoretical solution			Number of cases in which the farmer and theoretical solutions were disjunct			Total number of cases in which all theoretical solutions were identical		
	G[a]	P[b]	E[c]	G	P	E	G	P	E	G	P	E
	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.
1	12	13	13	0	0	0	1	0	0	13	13	13
2	6	11	5	12	10	10	4	5	4	22	26	19
3	4	5	3	6	6	6	3	2	1	13	13	10
4	0	0	0	7	6	5	0	0	0	7	6	5
5	0	0	0	3	6	3	0	0	0	3	6	3
7	0	1	0	1	0	1	1	1	1	2	2	2
8	0	0	0	0	0	0	0	0	0	0	0	0
Total	22 37%	30 45%	21 40%	29 48%	28 42%	25 48%	9 15%	8 13%	6 12%	60 100%	66 100%	52 100%

[a]G denotes the problem setting with good weather certain.

[b]P denotes the problem setting with poor weather certain.

[c]E denotes the problem setting with either good or poor weather possible.

cedures. But, as the following discussion of Table 15 indicates, this does not imply that the theories played any extensive descriptive role.

Of the 155 farmer solutions that included the theoretical solution at least in part, 24 per cent could hardly avoid being correct; they related to "problems" involving only a single feeder program[1]. Another 35 per cent of these 155 farmer solutions related to farmers who considered only two alternatives. Only in one case out of the 36 in which more than three acts were considered, was a strategy corresponding exactly to the theoretical solution chosen. Moreover, in the majority of those cases where the farmer's solution overlapped the theoretical solution, the optimal act was only of minor importance in the farmer's solution. Nor was there any significant correspondence evident between the farmers approaches to the short-run hypothetical decision problems (which correspond best in time influence to the practical problems) and the classification of the farmers' solutions in Table 15. Also, contrary to one's hopes, the solutions of those 24 farmers who considered more than one state of Nature did not correspond with the theoretical solutions to any greater extent than was evident for the other members of the panel.

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[1]In some respects, it would have been proper and convenient to exclude these trivial problems from Table 15 and its concomitant discussion. However, the presentation is simplified by their inclusion.

Purposive selection by the respondents, based on calculations akin to those involved in our construction of the payoff matrices and application of the decision algorithms, appears unlikely.

As is shown in the following paragraphs, a similar conclusion must be drawn from analysis of those problems not containing a dominant act. Also, for both solution groups, this conclusion remains true when Wald and Savage approach solutions based on only pure strategy selection are allowed.

All theoretical solutions not identical

Forty-seven of the 225 problems had payoff matrices such that the Laplace, Wald and Savage criteria solutions were not identical. The farmers' solutions of these problems are classified in terms of their agreement with the theoretical solutions in Table 16. In making this tabulation, the farmer's solution was regarded as coinciding with the theoretical if it included the acts of the normative solution in proportions within the range $y_i \pm 0.10$, where y_i is the fraction of resources that should be devoted to the i th act. The range $\pm$ 0.10 allows for possible errors of estimation in both farmer and normative solutions; errors deriving from inaccuracies in the data used to calculate production costs. To a degree, the range of $\pm$ 0.10 is arbitrary. However, it is

Table 16. Correspondence between farmer and theoretical solutions to the practical decision problems in those cases where all theoretical solutions were not identical

Number of alternatives considered	Number of cases in which farmer's solution in agreement with:												Total number of cases in which all theoretical solutions were not identical		
	Laplace solution			Wald solution			Savage solution			None of the theoretical solutions					
	G[a]	P[b]	E[c]	G	P	E	G	P	E	G	P	E	G	P	E
	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.	no.
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	0	1	2	1	4	1[d]	2[d]	1[d]	5	3	7	9	5	12
3	0	0	0	0	0	0	0	0	2	1	1	2	1	1	4
4	0	0	0	0	0	0	0	0	0	1	2	3	1	2	3
5	0	0	0	0	0	0	0	0	0	3	0	3	3	0	3
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
Total	2	0	1	2	1	4	1[d]	2[d]	3[d]	11	7	16	15	9	23

[a] G denotes the problem setting with good weather certain.

[b] P denotes the problem setting with poor weather certain.

[c] E denotes the problem setting with either good or poor weather possible.

[d] Including one problem already listed under agreement with the Wald solution.

thought to be not unreasonable[1].

Inspection of Table 16 reveals that only 16 of the 47 farmer solutions coincided with a theoretical solution. Fourteen of these instances were for problems involving only two acts. Of these 14 problems, 12 had theoretical solutions involving both alternatives in approximately equal proportions. The farmers may have tended to allocate their resources in similar proportions as a simple compromise between the two alternatives. The normative solutions to the other four of the 16 problems involved only pure acts. Coincidence between the farmer and theoretical solutions could again have been due to chance. Given the data of Table 16, this seems most likely. Also, no significant correspondence existed between the farmers' solutions to the hypothetical short-run decision problems and their solutions to the practical problems. This supports the contention that the farmers' analyses of the practical problems were not based on considerations akin to those used in deriving the normative solutions.

Alternative hypotheses

We cannot say that the Laplace, Wald and Savage theories played any significant descriptive role in relation to the

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[1]Howell, H. B. and Kutish, F. Department of Economics and Sociology, Iowa State College, Ames, Iowa. Errors in calculating cattle feeding costs. Private communication. 1958.

normative payoff matrices for the practical problems. This contrasts with the fact that in the hypothetical decision problems a majority of the farmers did tend to use a Laplace or Wald type of approach. Probably a multitude of factors contribute to this discrepancy. However, only three possible causes will be discussed here. They are hypothesized as the most important.

<u>Profit maximization</u> Profit maximization has been assumed to dominate the decision makers' appraisal of his problem. Perhaps this assumption is too strong; for instance, some of the decision makers may have preferences between alternative acts based on non-economic characteristics of the acts. Others may gamble for its own sake.

<u>Strangeness of the model</u> As shown in Chapter VII, only a minor proportion of the farmers approached the decision problem in a manner similar to that postulated by the normative model. The "strangeness" of the constructed decision problem with its implicit use of the model may have confused many of the respondents.

<u>Calculation difficulties</u> In making our analysis, we have used normative payoff matrices. As shown in Appendix E and F, the development of these matrices involved a series of cumbersome calculations. Implicitly, we assumed that the respondents would also make these calculations, or know in-

tuitively from previous experience the adjustments that had to be made. Without doubt, this is an extremely strong assumption. Its lack of fulfillment is probably the major cause for the high degree of irrationality shown in the farmers' solutions. However, the fact that the farmers did not make the transformations from expected prices to expected profits correctly, does not necessarily vitiate the descriptive role of the theories. The farmers may have been using the theories, not in relation to the normative payoff matrices, but in terms of some naive set of payoffs.

Naive payoffs The simplest such hypothesis is that the farmers made their choices simply in terms of the expected buying and selling prices of the cattle; no account being taken of intermediate production costs. To test this hypothesis, payoff matrices were constructed for each problem in terms of the margins between expected buying and selling prices for each alternative. The farmers' solutions were checked against the theoretical solutions for this naive formulation of the decision problems. Again no significant correspondence was found between the theoretical and empirical solutions; nor between the farmers' solutions to the practical problems and their decision making approach to the short-run hypothetical problems. The hypothesis must be dismissed.

Habitual selection An alternative hypothesis is that the farmers did not solve the constructed problem in an active way; perhaps they had a rather fixed feeder cattle operation from year to year which they nominated as their solution to the problem. As a test of this hypothesis, the farmers' solutions to the practical problems were checked against the history of their feeder enterprises during the two previous seasons. The 13 farmers who considered only a single alternative were excluded from this phase of the analysis. Of the remaining 62 farmers, 21 per cent had solutions to the practical problems coinciding either exactly or very closely with their actual feeder programs over the two previous years. They apparently made their feeder cattle decisions on a habitual basis; when confronted with the practical decision problem they had probably reiterated the habitual solution. It appears certain that for these 13 farmers, and for the 13 who considered only a single alternative, the decision theories we have elaborated played no descriptive role in the short-run of a single season. It may be that the theories played some role over the longer run for these farmers in initially determining their habitual decision; more likely, though, their original longer run decision was based on an aspiration level approach of the Simon type. Perhaps they found a feeder enterprise pattern that was initially satisfactory and simply maintained this same pattern, never seeking better alternatives.

Nothing has been said of the 49 respondents whose feeder operation varied within the two prior seasons. In general, they nominated solutions that varied over the three problem settings and were, in consequence, usually different from either of their two historical selections. These farmers, therefore, probably approached the practical problems in an active manner. Moreover, they constitute the bulk of the population. On these grounds, we cannot dismiss the theories as playing no role with respect to the practical problems. They may have been used by a few or many members of the population - even though we have been unable to specify their operational bases. However, the theories assuredly were not used in terms of the normative model implicit in our original construction of the payoff matrices for the practical problems. *Ipso facto*, it is to be expected that the theories have normative value; their use should reduce *ex ante* resource misallocation. The correctness of this expectation is assessed in the following section.

Normative Role of the Theories of Choice: Practical Decision Problems

The average expected annual per cent net return from the farmer, Laplace, Wald and Savage solutions for each state of Nature in each problem setting is shown in Table 17. Inspection of the table reveals that these returns differ little from state to state within each solution. Also, only relatively small differences exist between the average payoffs for the Laplace, Wald and Savage solutions. Given the prevalence of dominant alternatives, this is not unexpected. The outstanding feature of the data is the difference between the farmer and normative solutions. For every state of Nature in every problem setting, the average expected payoff from the farmer solutions is markedly smaller than that from any of the three normative solutions.

Table 17. Average expected annual per cent net return under each state of Nature for the farmer's, Laplace, Wald and Savage solutions of the practical decision problems

Solution	Good weather certain		Poor weather certain		Either good or poor weather possible			
	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
Farmer	20.5	19.0	18.0	18.9	20.1	19.9	18.1	18.1
Laplace	25.4	23.8	23.5	22.9	24.9	23.8	23.4	22.9
Wald	25.2	23.8	23.0	23.0	24.8	23.9	23.0	22.8
Savage	25.2	23.8	23.3	23.0	24.8	23.8	22.9	22.5

Assuming the survey panel to be a random sample, F tests based on analysis of variance using designed comparisons among the means (76, pp. 254-256) of Table 17 indicate that the differences between the farmer and theoretical solution means are highly significant[1]; also that significant differences do not

[1]The value of the F statistic was 151.

exist among the theoretical solution means[1].

Table 18 lists the magnitude of the average discrepancies between the farmer and normative solution payoffs. The percentage increase in net return that would be expected if the normative strategy had been selected rather than the farmers' nominated solution is shown in Table 19. Obviously the decision theories examined do have practical normative import *ex ante*. Nothing can be said of their role in reducing *ex post* resource misallocation. The extent to which they did so would depend on the correctness of the farmers' price expectations.

Table 18. Average gain in expected annual per cent net return under each state of Nature that would occur if the farmers used the Laplace, Wald or Savage criteria

Criterion	Good weather certain		Poor weather certain		Either good or poor weather possible			
	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
Laplace	4.9	4.8	5.5	4.0	4.8	3.9	5.3	4.8
Wald	4.7	4.8	5.0	4.1	4.7	4.0	4.9	4.7
Savage	4.7	4.8	5.3	4.1	4.7	3.9	4.8	4.4

Perusal of Table 19 also shows that the three normative theories do not differ greatly in the extent to which they reduce resource misallocation *ex ante* - as would be expected given the data of Table 17. None the less, some noteworthy

[1] The value of the F statistic was less than one.

Table 19. Average percentage increase in expected annual per cent net return under each state of Nature that would occur if the farmers used the Laplace, Wald or Savage criteria

Criterion	Good weather certain		Poor weather certain		Either good or poor weather possible			
	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
Laplace	23.9	25.3	30.5	21.2	23.9	19.6	29.3	26.5
Wald	22.9	25.3	27.8	21.7	23.4	20.1	27.0	26.0
Savage	22.9	25.3	29.4	21.7	23.4	19.6	26.5	24.3

differences do exist. In the problem setting with good weather certain, the average expected payoffs from the Wald and Savage solutions are dominated by those from the Laplace solutions. With poor weather assured, the Wald approach is dominated. On the other hand, with weather unspecified, the Savage approach is inferior to the Laplace and Wald algorithms. That the Laplace solutions are never dominated, while the Wald and Savage are, is not surprising. It reflects the conservatism of the Wald and Savage approaches. However, as the figures show, this conservatism may not be very important.

The data of Table 19 can also be interpreted as an indication of the extent to which the survey farmers tended to be irrational, assuming profit maximization as their goal. Table 20 gives a better indication of the degree of irrationality that prevailed. It presents frequency distributions of the discrepancies between the farmer and Laplace criterion solutions under each state of Nature. Had they used the

Table 20. Frequency distributions of the change in expected annual per cent net return that would occur if the farmers used the Laplace criterion

Interval	Good weather certain S_1	Good weather certain S_2	Poor weather certain S_3	Poor weather certain S_4	Either good or poor weather possible S_1	S_2	S_3	S_4
	no.	no.	no.	no.	no.	no.	no.	no.
-15.0 to -10.1					1			
-10.0 to -5.1				1	1			
-5.0 to -0.1	2	6	1	4	3	10	2	5
0.0 to 4.9	40	43	43	47	40	42	41	43
5.0 to 9.9	15	10	17	13	17	14	19	19
10.0 to 14.9	13	10	7	4	6	3	6	1
15.0 to 19.9	3	1	3	3	2	2	4	3
20.0 to 24.9	2	4	1	2	4	4	1	2
25.0 to 29.9		1	1	1	1			1
30.0 to 34.9			1				2	1
35.0 to 39.9								
40.0 to 44.9			1					

Laplace criterion, 17 per cent of the farmers would, on average, have increased their expected net return by 10 or more percentage points; six per cent of the farmers would have decreased their net return. Because the frequencies for the Wald and Savage criteria follow essentially the same pattern, they are not presented.

It is interesting to examine Table 19 from the point of view of an extension worker. What decision procedures should he recommend to the members of the population, assuming the farmers correctly formulate the payoff matrices? To the extension worker, the three sets of data of Table 19, one for each problem setting, constitute three decision problems under absolute uncertainty. The decision approach he should recommend in each setting would then vary as follows, depending on which criterion he himself used in solving these three problems:

Decision procedure used by extension worker	Decision procedure to be recommended with:		
	Good weather certain	Poor weather certain	Either good or poor weather possible
Laplace	Laplace	Laplace	Laplace
Wald	Laplace	Savage	Wald
Savage	Laplace	0.69 Laplace 0.31 Savage	0.82 Laplace 0.18 Wald

Only if he used the Savage approach would the extension worker ever need to recommend a randomized mixture of decision procedures.

Summary

Five questions were posed in the introduction to this chapter. They are reiterated below, together with a brief summary of the answers relevant to the survey panel elaborated in the text.

1. To what extent do the theories have descriptive value?

Examination of the farmers' solutions to a set of hypothetical decision problems indicated that a majority of the farmers tended to use an approach similar to either the Laplace or Wald procedures. Also, it was evident from the respondents' answers that Shackle's claim to have a general descriptive explanation of decision making must be dismissed. From comparison of the farmer and theoretical solutions to a set of practical decision problems nothing could be said of the descriptive roles of the theories *per se*. It was apparent, however, that the theories played no descriptive role in terms of the normative model underlying the practical problems.

2. How stable is the decision maker's approach to decision making as the setting of the decision problem varies?

One third of the respondents did not vary their decision making approach over the four settings of the hypothetical problem. The remainder of the farmers adopted a less conservative approach as the income uncertainty inherent in the problem decreased; of this remainder, a majority shifted from a Wald type of approach, using the Laplace criterion in its stead; a minority, using the Laplace criterion when no sure income was available, discarded it in favor of a "gambling" approach when an additional sure income was available. The length of time over which the decision would be influential did not appear to be as important as the income context of the problem in determining the decision approach followed. Some of the respondents tended to follow a less conservative approach when the problem had only short-run repercussions; a few behaved conversely.

3. So far as the theories are descriptively true, what characteristics of a decision maker's background tend to be associated with the selection of a particular approach to the decision problem?

Among the population studied, consistent use of a Wald type of approach tended to be associated with a low level of total capital investment and a very high equity ratio. These respondents were also, on average, the older and least educated members of the population. Those who always used the Laplace algorithm generally had the most years of formal education, a relatively high net worth and a low equity ratio. In contrast with those using only a Wald or a Laplace approach were those farmers who switched between these two procedures. On the average they were wealthier, younger and had more dependents. Assuming the respondents to be a random sample of 30 to 50 year old Corn Belt owner-operators with a feeder cattle enterprise, none of the differences in attributes mentioned above were statistically significant.

4. For those theories advanced as normative decision criteria, what value might they have in reducing *ex ante* resource misallocation?

In every practical problem setting examined, the respondents would have been able to increase their expected net return by at least 21 per cent on the average if they had used the Laplace, Wald or Savage procedures. Assuming the survey panel to be a random sample of 30 to 50 year old Corn Belt owner-operators with a feeder cattle enterprise, the average increases in expected net return that would have been obtained by use of the normative criteria, instead of the farmer's own solution, were statistically significant. Obviously, the Laplace, Wald and Savage theories do have normative value in the practical situation studied.

5. Are there noteworthy differences between the various normative decision criteria in the degree to which they reduce *ex ante* resource misallocation?

For the situation examined, there were no salient differences between the Laplace, Wald and Savage algorithms in terms of the extent to which they reduced *ex ante* resource misallocation.

IX. SUMMARY OF PROCEDURES, CONCLUSIONS AND LIMITATIONS

Invariably, real-world economic decisions are clouded by uncertainty about the future. This study has been concerned with decisions made under one type of uncertainty - that described as absolute. In such circumstances the decision maker has no objective knowledge of the likelihood of occurrence of the possible outcomes of his decision. He knows only what outcomes may occur.

Is absolute uncertainty of any economic significance? Part I of the dissertation considered this question. A game theoretic model of the production decision problem facing an entrepreneur was constructed. Assuming an economic hierarchy of the type and magnitude generally found in the real-world, the game theory approach proved unsatisfactory. Its assumptions were too demanding. However, by realizing the implications of a situation involving a large number of entrepreneurs whose production decisions interact and all of whom have only human capabilities, a more satisfactory model was derived. Essentially, this model was normative; being postulated as the most rational way for the entrepreneur to view the production decision problem. It met the exigencies of the real-world situation by assuming that the decision maker simplified his choice problem to a degree compatible with his mental capabilities; appraising only some subset of his available acts and confining his attention to a small number of states of Nature. These states of Nature were specified as broad aggregative maneuvers possible on the part of his opponents considered _en masse_. The logical implication of this model is that the production decision problem is one under absolute uncertainty - so long as opponents are so numerous that they cannot be taken into account individually. Since many entrepreneurs operate under such circumstances, each facing many production decision problems, absolute uncertainty is not without economic significance.

Using the constructed model, an empirical assessment of the normative and descriptive roles of a number of theories of choice relevant to absolute uncertainty was attempted in Part II. Some of these theories are primarily normative. Such are those of Laplace, Wald, Savage and Hurwicz. However, being but simple algorithms, it is not implausible that these theories might have descriptive value. The remaining theories - those of Simon and Shackle - are purely descriptive; they have no normative connotation.

For the empirical analysis, data were collected during 1956-57 by way of a four stage personal interview panel survey. The panel constituted a population of 77 respondents all of whom:

(1) were farming in Marshall County, Iowa;

(2) were aged between 30 and 50 years in June, 1957;

(3) had owned and operated at least 80 acres of farmland

during the three years prior to June, 1957;

(4) had fed an average of at least 25 feeder cattle in each of the three feeding seasons prior to the survey;

(5) cooperated in all stages of the survey.

The above restrictions ensured that the respondents were familiar with the feeder cattle enterprise. This was important, the empirical analysis being based upon the decision problem facing a Mid-West farmer within his feeder cattle enterprise at the pre-purchase planning stage of a given season. It was possible to specify this problem in terms of the normative model constructed in Part I. However, examination of the farmers' responses revealed that only 12 out of the 77 could be said fairly certainly to consider the decision problem in the fashion postulated by the model. For another three farmers, the model was probably descriptively correct. In its entirety, the model therefore had descriptive value for only a small proportion of the population. None the less, a majority of the farmers behaved in partial agreement with the model: all considered some simplified subset of the alternatives available to them; 58 specified as a primary factor influencing their choice a factor compatible with the theoretical specification of the model; 24 of the respondents made allowance for outcome variations over two or more states of Nature.

To assess the possible normative and descriptive roles of the theories, the respondents were asked to solve two sets of decision problems under absolute uncertainty.

The first of these sets consisted of four hypothetical problems. The farmers' solutions to these problems, together with their raisons d'être for the choices made, indicated that probably only the Wald and Laplace theories had any significant descriptive value. Also, it was evident from the respondents' answers that Shackle's claim to have formulated a general descriptive explanation of decision making must be dismissed. Moreover, only a minority of the farmers consistently used the same approach to each of the hypothetical decision problems. It is certain that the decision approach used, and consequently the choice made, depends to a large extent on the setting of the decision problem. In this regard, our analysis revealed that within a practical range of income and time influence contexts, income was more important than the time influence of the decision in determining which decision approach would be used. Consistent use of a Wald type of approach tended to be associated with a low level of total capital investment and a very high equity ratio. On average, these respondents were also the older and least educated members of the population. Those who always used the Laplace algorithm generally had the most years of formal education, a relatively high net worth and a low equity ratio. In contrast with those farmers using only a Wald or a Laplace approach were those respondents who switched between these two procedures as the setting of the decision problem varied. Generally, they were wealthier, younger, and had more dependents. Moreover, they were numerically more important than either of the groups using only a Wald or only a Laplace type of approach.

The other set of problems were practical. They related to a real-world situation. Each respondent was asked for data relevant to his pre-purchase decision problem within the feeder cattle enterprise. Given this data, the farmer was asked for his solutions to this problem when it was posed in three different contexts. From comparison of the farmers' and the theoretical solutions to these practical problems nothing could be said of the descriptive roles of the theories *per se*. It was apparent, however, that the theories played no descriptive role in terms of the normative model underlying the construction of these practical problems. Conversely, the possible normative role of the theories was noteworthy. In every setting of the practical problems, the respondents would have been able to increase their expected profits by at least 21 per cent on the average if they had used the Laplace, Wald or Savage procedures.

While there were no salient differences between these algorithms in the extent to which they reduced *ex ante* resource misallocation, the Wald and Savage procedures did tend to be more conservative than the Laplace algorithm.

Throughout the analysis, limitations abound. They are unavoidable in an exploratory study. For the convenience of the cursory reader, the major shortcomings are summarized below.

Firstly, profit maximization was assumed to be the dominant goal of the entrepreneur. Ideally, it would have been better to have worked in terms of utility. It would also have been impractical.

Secondly, our empirical analysis assumed that the respondent's solution to a constructed decision problem corresponded exactly with the decision and resultant action he would have taken if faced with that same problem in real life. To overcome this limitation would be extremely difficult. It seems certain that attempts to observe real life decisions and determine their *raisons d'être* would be frustrated by an effect of the Heisenberg type (8, pp. 38-40).

Thirdly, the respondents were only asked to solve each decision problem once. Had they been asked to solve the problems at other points in time they may have given different answers. Our analysis has made no allowance for any randomness of response. Of course, this is a shortcoming to be found in most research based on personal interview surveys.

Fourthly, the empirical analysis related, in strict terms, only to a population of 77 farmers[1]. Moreover, much of the study revolved around but one of the many production decision problems faced by these entrepreneurs. Nor was allowance made for interaction between these many decision problems.

Other limitations are discussed in the text. They are felt to be less important than those listed above. No doubt all of them are significant to some extent. Whether they vitiate the analysis so that it must be taken *cum grano salis* is a decision the reader must make. However, prior to making this decision, he should read the body of the dissertation.

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[1]However, in assessing the normative and descriptive roles of the theories of choice, the data were also analyzed statistically as if it were derived from a random sample of 30 to 50 year old Corn Belt owner-operators with a feeder cattle enterprise.

X. ACKNOWLEDGMENTS

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For bearing so well the many sacrifices entailed by his graduate study, the author gratefully thanks his wife and children.

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XI. APPENDIX A: CHARACTERISTICS OF THE POPULATION

The mean and range of some selected attributes of the survey farmers are shown in the accompanying tables. Personal characteristics are summarized in Table 21, financial data in Table 22 and farm organization characteristics in Table 23.

A wide range is evident for a majority of the characteristics. With the exception of equity, which has a slightly negatively skewed distribution, all of the attributes listed in Tables 22 and 23 have a frequency distribution that is strongly positively skewed. Typical is the distribution of operated acres. It is as follows:

Acres operated	Number of farmers
80- 99	3
100-199	24
200-299	21
300-399	17
400-499	7
500-599	3
1100	1
1820	1

Perusal of the above figures shows that the population contained two farmers with extremely large farms. Averages of the more important characteristics of the survey panel, calculated with these two farmers excluded, are given in Table 1 on page 48 of the text.

Table 21. Selected personal characteristics of the population[a]: mean and range

Item	Unit	Mean	Range Low	Range High
Age	year	42.1	31	50
Dependents	no.	3.6	0	7
Education				
School	year	11.0	4	12
College	year	0.6	0	5
Total	year	11.6	4	17
Work Experience				
Full-time non-farm	year	2.0	0	25
Farm laborer	year	4.8	0	16
Tenant	year	5.7	0	26
Experience as owner-operator				
Current farm	year	10.5	3	25
Total	year	11.4	3	27

[a]As at June, 1957.

Table 22. Selected financial characteristics of the population[a]: mean and range

Item	Unit	Mean	Range	
			Low	High
Invested capital				
Land and buildings	$1,000	72.8	5.0	450.0
Machinery	$1,000	11.1	1.0	50.0
Livestock	$1,000	18.2	0.0	140.0
Other[b]	$1,000	31.5	0.3	805.0
Total capital investment	$1,000	133.6	20.1	1,300.0
Borrowed capital				
Land, buildings and machinery	$1,000	9.5	0.0	56.0
Livestock	$1,000	3.2	0.0	26.0
Other[c]	$1,000	2.8	0.0	30.0
Total borrowed capital	$1,000	15.5	0.0	102.0
Equity ratio	per cent	88.4	52.6	100.0
Gross income[d]	$1,000	49.1	8.0	680.0
Gross farm income[d]	$1,000	41.9	8.0	442.0

[a]Calculated from farmers' estimates as of July 1, 1957.

[b]Operating capital, feed, stocks and bonds, and nonfarm investment.

[c]Mainly unsecured notes.

[d]Average over 1954, 1955 and 1956.

Table 23. Crop and livestock programs followed by the population[a]: mean and range

Item	Unit	Mean	Range Low	Range High
Land Operated	acre	291.4	80	1,820
Owned	acre	239.3	80	1,820
Rented	acre	52.1	0	335
Land Use[b]				
Grain[c]	acre	145.5	0	900
Soybeans	acre	8.4	0	63
Silage	acre	8.7	0	200
Hay	acre	43.1	0	200
Rotation pasture	acre	24.9	0	500
Permanent pasture	acre	24.1	0	285
Homestead, lots and waste	acre	11.8	2	110
Total	acre	266.6	80	1,820
Livestock				
Pig litters	no.	32.4	0	100
Feeder cattle purchased	no.	137.4	9	1,200
Calves	no.	67.3	0	900
Yearlings	no.	63.6	0	817
Two-year olds	no.	6.5	0	140
Beef cows	no.	6.9	0	57
Milking cows	no.	2.6	0	40

[a]During the 1956-57 season.

[b]Total of owned land plus share of rented land.

[c]Including Soil Bank which averaged 3.6 acres per farm.

XII. APPENDIX B: SURVEY QUESTIONNAIRES

The schedules used in collecting the empirical data used in this study are presented on the following pages. Where convenient, the spatial arrangement of the original questionnaires has been abbreviated.

Schedule A was completed in June, 1957; Schedule B in August, 1957; Schedule C in October, 1957; and Schedule D in January, 1958. Schedules A, B and C were completed by way of personal interview. Schedule D was mailed to the respondents; those not returning the schedule, or returning an incomplete schedule, were contacted by telephone.

Data relevant to the dissertation were derived from the respondents' answers to the following questions:

Schedule A: I; III; IV; V; VIII.

Schedule B: IV; VII; VIII; IX; X.

Schedule C: IV; VII; VIII; IX.

Schedule A

Confidential

Farm no.__________
Enumerator__________

BEEF FEEDER STUDY

Conducted by the Department of Economics and Sociology, Iowa State College, Ames, Iowa.

I. GENERAL INFORMATION

1. Name____
2. Mailing address_______________ 3. Phone no.____________
4. Total acres operated____; acres owned___;acres rented__
5. Age______ 6. Highest year of school finished__________
7. Years farming as owner-operator____; on this farm_____
8. Years operating as tenant________
9. Years worked as farm laborer______
10. Full-time nonfarm work experience: Position__________

    Years_____________
11. Number of dependents_____

II. EXPECTATIONS OF CORN AND HOG SELLING PRICES

("Low" and "high" are extremes of range in which it is expected there are 9 chances out of 10 that the price will fall.)

Mid-month	CORN No. 2 Yellow Local market			HOGS 225 lb. Specify market_____		
	Low	High	Most probable	Low	High	Most probable
September '57	xx	xx	xx			
October '57	xx	xx	xx			
December '57				xx	xx	xx
March '58	xx	xx	xx			
April '58						
August '58				xx	xx	xx

III. CROPPING PROGRAM

(Circle double cropping)

	Last year			Expected this year		
	Acres planted	Acres harvested & no. of hay cuts	Yield per harvested acre	Acres planted	Acres harvested	Yield per harvested acre
Corn grain						
Corn silage						
Soil Bank						
Oats grain						
Oats pastured						
Soybeans						
Sorghum grain						
Sorghum silage						
Alfalfa hay						
Clover hay						
Other hay						
Alfalfa rot'n pasture						
Clover rot'n pasture						
Perm. Pasture						

Reasons for major changes between last year and this year:

IV. LIVESTOCK PROGRAM

Enterprise	Last 12 months	Planned coming 12 months
Litters fall pigs July 1 - Dec. 31		
Litters spring pigs Jan. 1 - June 31		
Cows milked	spring '57	spring '58
Dairy heifers 1 year old	spring '57	spring '58
2 years old		
Beef cows calved	spring '57	spring '58
Beef heifers 1 year old	spring '57	spring '58
2 years old		
Feeder or stock calves sold		
Feeder cattle purchased		
Ewes lambed	spring '57	spring '58
Laying hens	spring '57	spring '58

Reasons for major changes between last 12 months and coming 12 months:

V. 1. FEEDER ENTERPRISE: SEASON BEGINNING JULY 1, 1956

Buying type and quality	Buying details				Selling details				
	Price at farm	No.	Month	Weight	Price at farm	Grade	Weight	No.	Month
Mostly Drylot 2 Yr. Olds									
Choice									
Good									
Medium									
Common									
Yearlings									
Choice									
Good									
Medium									
Common									
Steer Calves									
Choice									
Good									
Medium									
Mostly Pasture Fed Yearlings									
Choice									
Good									
Medium									
Calves									
Choice									
Good									
Medium									

V. 2. FEEDER ENTERPRISE: SEASON BEGINNING JULY 1, 1955

Buying type and quality	Buying details				Selling details				
	Price at farm	No.	Month	Weight	Price at farm	Grade	Weight	No.	Month
Mostly Drylot									
2 Yr. Olds									
Choice									
Good									
Medium									
Common									
Yearlings									
Choice									
Good									
Medium									
Common									
Steer Calves									
Choice									
Good									
Medium									
Mostly Pasture Fed									
Yearlings									
Choice									
Good									
Medium									
Calves									
Choice									
Good									
Medium									

V. 3. FEEDER ENTERPRISE: PLANS FOR SEASON BEGINNING JULY 1, 1957

Buying type and quality	Buying details				Selling details				
	Price at farm	No.	Month	Weight	Price at farm	Grade	Weight	No.	Month
Mostly Drylot 2 Yr. Olds									
Choice									
Good									
Medium									
Common									
Yearlings									
Choice									
Good									
Medium									
Common									
Steer Calves									
Choice									
Good									
Medium									
Mostly Pasture Fed Yearlings									
Choice									
Good									
Medium									
Calves									
Choice									
Good									
Medium									

VI. EXPECTATIONS OF FEEDER CATTLE PRICES

Specify market in mind:______________________

("Low" and "high" are extremes of range in which it is expected there are 9 chances out of 10 that the price will fall.)

Age type	Quality and weight	Mid-August			Mid-September			Mid-October			Mid-November		
		Low	High	Most probable	Low	High	Most Probable	Low	High	Most probable	Low	High	Most probable
Steers	Choice 500-800 lb.												
	Choice 800-1100 lb.												
	Medium 800-1000 lb.												
Calves 300-500 lb.	Good-choice steers												
	Medium steers												

VII. EXPECTATIONS OF FAT CATTLE PRICES

Mid-month	CHOICE STEERS: Specify market______					
	900-1100 lb.			1100-1300 lb.		
	Low	High	Most probable	Low	High	Most probable
Dec. '57						
Jan. '58						
Feb.						
Mar.						
Apr.						
May						
June						
July						
Aug.						

VIII. CAPITAL POSITION

		As at July 1, 1957	Expected July 1, 1958
1. Sale value of land and buildings	this farm	______	______
Sale value of livestock		______	______
Sale value of machinery and equipment		______	______
Sale value of feed stored		______	______
Cash on hand or in bank		______	______
Government bonds		______	______
Corporation stocks and bonds		______	______
Amount of money owed to you		______	______
Sale value of other farm property		______	______
Sale value of other property		______	______
2. Farm mortgage		______	______
Chattel mortgage		______	______
Unsecured notes payable by you		______	______
Household installment debts		______	______
Other debts (tax, store, etc.)		______	______

IX. CAPITAL HISTORY

1. Total capital owned when started farming

   as tenant____________; as owner____________

2. Amount borrowed when started farming

   as tenant____________; as owner____________

3. Amount inherited before starting as tenant__________

   while tenant__________

   since became owner______

4. Average gross income from all sources in last three years____________

5. Percentage of this average gross income from farming__

Schedule B

Confidential

Farm no.___________
Enumerator__________

BEEF FEEDER STUDY

Conducted by the Department of Economics and Sociology, Iowa State College, Ames, Iowa.

I. EXPECTATIONS OF CORN AND HOG SELLING PRICES

("Low" and "high" are extremes of range in which it is expected there are 9 chances out of 10 that the price will fall.)

Mid-month	CORN No. 2 Yellow Local market			HOGS 225 lb. Specify market______		
	Low	High	Most probable	Low	High	Most probable
September '57	xx	xx	xx			
October '57	xx	xx	xx			
December '57				xx	xx	xx
March '58	xx	xx	xx			
April '58						
August '58				xx	xx	xx

II. CORN YIELD EXPECTATIONS

1. What average yield per acre do you now expect on your corn?__________
2. In how many years out of ten do you think you can fairly successfully forecast the coming national corn crop in: mid-July____; mid-August____; and mid-September____.
3. What sort of national corn crop do you expect this season compared with the average over the last five seasons? _______% more; _____% less

III. FEEDER ENTERPRISE TRANSACTIONS SINCE JUNE 30

Sales					Purchases				
Purchase type	Selling grade	Price at farm	No.	Weight	Type	Grade	Price at farm	No.	Weight

IV. CHANGES IN PLANS SINCE JUNE FOR 1957-58 FEEDER ENTERPRISE

Buying type and quality	Buying details				Selling details				
	Price at farm	No.	Month	Weight	Price at farm	Grade	Weight	No.	Month
Mostly Drylot 2 Yr. Olds									
Choice									
Good									
Medium									
Common									
Yearlings									
Choice									
Good									
Medium									
Common									
Steer Calves									
Choice									
Good									
Medium									
Mostly Pasture Fed Yearlings									
Choice									
Good									
Medium									
Calves									
Choice									
Good									
Medium									

V. EXPECTATIONS OF FEEDER CATTLE PRICES

Specify market in mind: ______________________

("Low" and "high" are extremes of range in which it is expected there are 9 chances out of 10 that the price will fall.)

Age type	Quality and weight	Mid-September			Mid-October			Mid-November		
		Low	High	Most probable	Low	High	Most probable	Low	High	Most probable
Steers	Choice 500- 800 lb.									
	Choice 800-1100 lb.									
	Medium 800-1000 lb.									
Calves 300-500 lb.	Good-choice steers									
	Medium steers									

VI. EXPECTATIONS OF FAT CATTLE PRICES

Mid-month	CHOICE STEERS: Specify market________					
	900-1100 lb.			1100-1300 lb.		
	Low	High	Most probable	Low	High	Most probable
Dec. '57						
Jan. '58						
Feb.						
Mar.						
Apr.						
May						
June						
July						
Aug.						

VII. INFORMATION

1. Do you actively seek information on what kind of feeder cattle other farmers have bought or are interested in buying before you decide your buying policy?__________. From what sources?_______________
2. Do the cattle outlook forecasts of such bodies as the USDA and ISC generally help, harm or not affect your feeder enterprise before you buy________; after you buy__. If harm, why?_____________________
3. Do you attempt to keep other beef feeder operators in the dark as to what your feeder plans are?________

VIII. ROLE OF THE WEATHER AND OTHER POSSIBLE INFLUENCES

1. Do you consider the type of weather that prevails throughout the Corn Belt in a given cropping season to be of any influence in determining whether that season would be good or bad, profit wise, for feeder cattle?_____________
2. Which of the following statements, if any, best describes the way in which you normally think of your feeder cattle operation in relation to the national feeder operation in a given year?

   (a) yourself versus all the other farmers who have feeders.

   (b) yourself versus all other farmers with feeders and the meat packers.

(c) yourself versus the meat packers.

(d) if none of the above, how do you think of the situation?________________________________

3. <u>If (a) or (b)</u>. Do you think of these other beef feeders as being:

(i) just as much in opposition to one another as to you; or as

(ii) a group mainly opposed to you rather than to one another; or as

(iii) a number of broad groups, the members of a given group being more in opposition to farmers in other groups than they are to one another. If (iii), what groups do you think of?________________

4. <u>If (b) or (c)</u>. Do you think of the meat packers as:

(i) being joined in a single group in opposition to you; or as

(ii) each acting individually in opposition to you; or as

(iii) acting as a group at each market but being in opposition between the different markets; or as

(iv) sometimes acting in a group but at other times split up and opposing one another as well as you.

IX. FEEDER PROGRAM ALTERNATIVES

1. In planning your feeder cattle enterprise, what alternative feeder programs do you normally give consideration to?

Buying				Feed program	Selling			Alternative no.
Type	Grade	Weight	Month		Grade	Weight	Month	

2. What do you think your most probable buying and selling prices at the farm would be for each of these alternative programs under each of the following circumstances? Assume that the feeder raisers behave in average or normal fashion.

Alternative no.	Good crop weather thru Corn Belt. (corn av. $1.10 thru season)				Poor crop weather thru Corn Belt. (corn av. $1.30 thru season)			
	Other farmers mainly short-feeding, selling March to June		Other farmers mainly long-feeding, selling June to September		Other farmers mainly short-feeding, selling March to June		Other farmers mainly long-feeding, selling June to September	
	Buying price	Selling price	Buying price	Selling price	Buying price	Selling price	Buying price	Selling price

3. Which alternative(s) would you follow, and with how many head of cattle in each, if you were sure that throughout the Corn Belt there would be:

   (a) good cropping weather:

   (b) poor cropping weather:

   (c) either good or poor cropping weather:

4. In making plans and purchases for your feeder enterprise each season, do you normally consider the problem, mentally or otherwise, in the fashion we have - with the possibility of cattle prices being one figure under one set of circumstances and other figures under other circumstances?_______. If yes, what possible circumstances do you normally take into account?________________

5. Do you think the way we have approached the problem of looking at your alternative feeder programs - with different prices being possible under different circumstances - to be a good, fair or poor way of looking at the problem of what feeder programs to follow?________________

X. CHOICE BETWEEN INVESTMENTS WITH UNCERTAIN RETURNS

A, B, C, and D are four different but equally costly types of annual farm investment. They are listed below with their possible dollar net incomes printed opposite them.

	Possible net income in dollars			
Investment A:	2,500	3,500	0	1,500
Investment B:	1,500	2,000	500	1,000
Investment C:	0	6,000	0	0
Investment D:	1,500	4,500	0	0

For each investment, the chance of obtaining, in a particular year, any particular one of the net incomes listed for that alternative is unknown; but you can be sure of getting one of the four net incomes listed. Suppose you select B and your net income turns out to be $1,000. Then if you had chosen C or D you would have got zero net income; if you had chosen A, you would have had a net income of $1,500.

Given your current circumstances, financial and otherwise, which investment would you select:

1. If you could only farm one year and have only one type of investment and

   (a) you had no other income source:______ Why?________

   (b) you had a certain income of $3,000 as well as this:________ Why?________

2. If you could farm for 20 years and only follow one type of investment and

   (a) you had no other income source:________ Why?______

   (b) you had a certain $3,000 as well:_______ Why?_____

Schedule C

Confidential

Farm no.__________
Enumerator__________

BEEF FEEDER STUDY

Conducted by the Department of Economics and Sociology, Iowa State College, Ames, Iowa.

I. EXPECTATIONS OF CORN AND HOG SELLING PRICES

("Low" and "high" are extremes of range in which it is expected there are 9 chances out of 10 that the price will fall.)

Mid-month	CORN No. 2 Yellow Local market			HOGS 225 lb. Specify market________		
	Low	High	Most probable	Low	High	Most probable
December '57				xx	xx	xx
March '58	xx	xx	xx			
April '58						
August '58				xx	xx	xx

II. CROP YIELDS FOR CURRENT SEASON

1. Hay: type________; acres__________; total tons________
2. Silage: type______; acres__________; total tons_______
3. Grain, ave. bus. per acre:

	actual yield (if harvest complete)	expected yield (if harvest incomplete)
____ acres of corn	__________	__________
____ acres of oats	__________	__________
____ acres of soybeans	__________	__________

III. FEEDER ENTERPRISE TRANSACTIONS SINCE MID-AUGUST

Sales					Purchases				
Purchase type	Selling grade	Price at farm	No.	Weight	Type	Grade	Price at farm	No.	Weight

IV. CHANGES IN PLANS SINCE AUGUST FOR 1957-58 FEEDER ENTERPRISE

Buying type and quality	Buying details				Selling details				
	Price at farm	No.	Month	Weight	Price at farm	Grade	Weight	No.	Month
Mostly Drylot 2 Yr. Olds									
Choice									
Good									
Medium									
Common									
Yearlings									
Choice									
Good									
Medium									
Common									
Steer Calves									
Choice									
Good									
Medium									
Mostly Pasture Fed Yearlings									
Choice									
Good									
Medium									
Calves									
Choice									
Good									
Medium									

V. EXPECTATIONS OF FEEDER CATTLE PRICES IN MID-NOVEMBER, 1957

("Low" and "high" are extremes of range in which it is expected there are 9 chances out of 10 that the price will fall.)

Feeder steers				Feeder steer calves 300-500 lb.			
Quality and weight	Low	High	Most probable	Quality	Low	High	Most probable
Choice 500- 800 lb.				Good-Choice			
Choice 800-1100 lb.				Medium			
Medium 800-1000 lb.				Market in mind__________			

VI. EXPECTATIONS OF FAT CATTLE PRICES

Mid-month	Choice Steers: Specify market__________					
	900-1100 lb.			1100-1300 lb.		
	Low	High	Most probable	Low	High	Most probable
Dec. '57						
Jan. '58						
Feb.						
Mar.						
Apr.						
May						
June						
July						
Aug.						

VII. FACTORS INFLUENCING FEEDER PROGRAM CHOICE

Would you list in order of importance, with comments if desired, the most important factors determining:

(a) The type of feeder program that you follow in a given season:______________________________

(b) The number of cattle that you buy in a given season:____

VIII. CLASSIFICATION OF CATTLE

1. To distinguish between one group of feeders and another on the basis of an average weight difference of one pound would not be very meaningful. On the other hand, to ignore an average difference of 300 pounds might not be wise. At what minimum difference in weight do you think it meaningful, although perhaps impractical, to make a distinction:

   (a) for steer calves:______________________________

   (b) for heifer calves:______________________________

   (c) for yearlings:______________________________

   (d) for two-year olds:______________________________

2. Likewise, what distinctions would you draw with respect to (i) time of purchase as feeders and (ii) time of sale as fat stock:

   (a) steer calves:______________________________

   (b) heifer calves:______________________________

   (c) yearlings:______________________________

   (d) two-year olds:______________________________

3. Buying quality distinctions:______________________________

4. Selling quality distinctions:______________________________

5. Feed program distinctions:______________________________

IX. MISCELLANEOUS

1. What is the highest per cent return on capital per year you feel you could be certain of obtaining if you invested the capital now tied up in your cattle in other ways? __%

2. To what extent do you use the capital that you invest in cattle for other investments during the period when it is not tied up in cattle? Owned capital___%. Borrowed capital_____%

3. Do you employ any labor, including family members, on a wage basis? If so, at what hourly wage?______________

4. In a normal season, approximately what proportion of the capital that you invest in your feeder enterprise do you borrow?________

Schedule D

CHANGES IN PLANS SINCE OCTOBER FOR 1957-58 FEEDER ENTERPRISE

Buying type and quality	Buying details				Selling details				
	Price at farm	No.	Month	Weight	Price at farm	Grade	Weight	No.	Month
Mostly Drylot 2 Yr. Olds									
Choice									
Good									
Medium									
Common									
Yearlings									
Choice									
Good									
Medium									
Common									
Steer Calves									
Choice									
Good									
Medium									
Mostly Pasture Fed Yearlings									
Choice									
Good									
Medium									
Calves									
Choice									
Good									
Medium									

XIII. APPENDIX C: FEEDER CATTLE PROGRAMS CONSIDERED BY EACH FARMER

The details of the alternatives considered by each farmer are shown in Table 24. They are recorded here for future reference; especially by those who may wish to study the effects of vertical integration on cattle feeding entrepreneurs, if and whenever it may become important.

In specifying the variables in the programs, the following abbreviations are used:

For age types: HC - heifer calves
SC - steer calves
Y - yearling steers
TYO - two-year old steers

For quality: M - medium
G - good
LC - low choice
C - choice
HC - high choice
P - prime

A combination of these symbols denotes a range of quality. Thus, G-C denotes good to choice quality.

For weight: Where a range of weights was specified the limits of the range are given. Thus, 1100-1200 denotes 1100 to 1200 pounds.

For months: Each month is referred to by a numeral corresponding to the order of the month in the calendar year. Thus, 9 signifies September. A range of months is denoted thus: 9-11, meaning September through November. Selling months normally refer to the calendar year following the buying months' calendar year. In some few cases, selling occurs in the second calendar year after buying. Such situations are easily identified by reference to the weight gain specified by the program.

Feed program: D - drylot

P - pasture

Table 24. Specifications of the alternative feeder cattle programs considered by each farmer[a]

Farmer number:	Considered alternative number:	Buying specifications				Feed program	Selling specifications		
		Age type	Quality	Weight in lb.	Month(s)		Quality	Weight in lb.	Month(s)
1	1	HC	M	500	6- 7	D	C	850	2
2	1	SC	G	550	8	D	G-C	1100	8
3	1	Y	G	600	9-10	D	G-C	1100-1200	7- 8
4	1	Y	C	600	9-10	D	HC	900-1000	3- 4
5	1	Y	G-C	700	9-10	D	C	1200	8- 9
6	1	Y	C	640	10	D	HC	1300	8
7	1	SC	C	350-450	9-10	D	C	1100	9-11
8	1	HC	C	400	10	P	HC	900	9
9	1	HC	G	425	11	D	G-C	850	5- 6
10	1	HC	G	400-450	12	D	G-C	850	7- 8
11	1	SC	C	400-450	9-11	D	C	1000-1100	8-10
12	1	SC	C	300-400	9-11	D	C	1000	9-11
13	1	Y	C	575	9-10	D	C	950-1050	3- 4

[a]The meanings of the symbols used in this table are explained in the introduction to Appendix C.

Table 24. (Continued)

Farmer number:	Considered alternative number:	Buying specifications Age type				Feed program	Selling specifications Quality		
		Age type	Quality	Weight in lb.	Month(s)		Quality	Weight in lb.	Month(s)
14	1	Y	M-G	600	9-11	P	G-C	1000-1100	5-6
	2	SC	G	350-400	9-11	P	G-C	1000	9-11
15	1	HC	C	350-450	9-11	P	C	850-1000	9-11
	2	HC	G	350-450	9-11	P	C	850-1000	9-11
16	1	HC	G	400	10	P	LC	900	10
	2	HC	G	400	10	D	LC	900	10
17	1	Y	C	600-700	9-11	D	C	1250-1350	7-9
	2	SC	C	400-500	9-11	P	C	1050-1150	10-12
18	1	SC	G-C	400-500	9-12	D	LC	950-1050	9-12
	2	Y	G-C	500-600	11-12	D	LC	1050-1150	9
19	1	Y	G	750	10	D	C	1100-1200	5
	2	HC	G	400	11	D	LC	800- 900	5
20	1	SC	C	450	10-11	D	HC	1050-1150	8-10
	2	Y	C	550	11-12	D	HC	1050-1150	8
21	1	Y	G	600-700	10	D	C	1050	6
	2	SC	G	450	10	D	C	1050	7
22	1	Y	G-C	500-600	9	D	G-C	975-1025	4
	2	SC	G-C	450	7	D	C	950-1050	5
23	1	Y	G	700	10-11	D	LC	1100-1200	4-6
	2	SC	LC	500	7	D	C	1100-1200	6

Table 24. (Continued)

Farmer number:	Considered alternative number:	Buying specifications: Age type	Buying specifications: Quality	Buying specifications: Weight in lb.	Buying specifications: Month(s)	Feed Program	Selling specifications: Quality	Selling specifications: Weight in lb.	Selling specifications: Month(s)
24	1	Y	G	550	10	D	C	1000	5-6
	2	HC	LC	400	11	D	C	850	8
25	1	SC	G-C	450	12	P	C	950-1050	10
	2	Y	G	600	12	D	C	1100	8
26	1	Y	G	600-700	10-11	D	G-C	1000	4-5
	2	HC	G	300-450	10-11	D	G-C	800	6
27	1	SC	G-C	350-450	9-11	D	C	900-1050	6-8
	2	SC	G-C	350-450	9-11	D	C	1050-1200	10-12
28	1	Y	C	600-650	9	D	P	1200	7
	2	SC	HC	400	9-10	P	P	1050-1150	11-12
29	1	SC	C	400-450	10-11	D	C	1100	10-11
	2	Y	C	650-700	10-11	D	C	1200	6
30	1	HC	C	525	9	D	C	900- 950	4-5
	2	SC	G	450	12	D	C	950-1000	5
31	1	Y	C	700	9-11	D	C	1300	6-8
	2	SC	C	400	10	P	C	1200	12
32	1	SC	G-C	425-475	10-11	D	C	1000-1100	9-10
	2	SC	G-C	425-475	10-11	P	C	1150-1250	10-11
33	1	Y	G-C	650-750	10	D	C	1150-1200	8-9
	2	SC	C	400-450	10-11	P	C	1050-1150	9-10

Table 24. (Continued)

Farmer number:	Considered alternative number:	Buying specifications Age type	Quality	Weight in lb.	Month(s)	Feed pro-gram	Selling specifications Quality	Weight in lb.	Month(s)
34	1	Y	G	550	10	P	C	1100	5
	2	SC	G	450	10	P	C	1100	9
35	1	Y	C	750	10	D	C	1100-1200	4-5
	2	SC	C	450	10	D	C	1150-1200	9
36	1	SC	G	400	10	P	C	1050	11
	2	SC	G	400	10	D	C	1000-1100	10
37	1	SC	G	400-600	10-11	D	C	900-1050	7-8
	2	HC	G	450-550	10-11	D	C	800- 900	4-5
38	1	SC	G	400	12	P	C	1000-1100	2
	2	TYO	M	800-900	12	P	M	1200	7
39	1	HC	C	325	11	D	C	850	7
	2	Y	C	550	11	D	C	950	6
40	1	SC	G-C	400	10-11	P	C	1000-1100	12
	2	Y	G-C	550-600	10-11	P	C	1000-1100	6-7
41	1	Y	C	500-550	9-11	P	C	1100-1200	9-11
	2	SC	C	450	9-11	P	C	1000-1100	9-11
42	1	Y	G	750	9	D	HC	1250-1400	4-5
	2	SC	C	400	11-12	P	C-P	1150	12
43	1	Y	C	600-700	8	D	C	1050-1150	5-6
	2	Y	G-C	550	8-9	D	C	900- 950	1-3

Table 24. (Continued)

Farmer number:	Considered alternative number:	Buying specifications				Feed program	Selling specifications		
		Age type	Quality	Weight in lb.	Month(s)		Quality	Weight in lb.	Month(s)
44	1	Y	C	750	10	D	C	1150-1250	6
	2	Y	C	600	10-12	P	C	1150-1250	9-11
45	1	SC	G-C	450	10-11	D	C	900-1100	10-11
	2	SC	G-C	450	8-9	D	C	900-1100	8-9
	3	SC	G-C	450	6-7	P	C	900-1100	7-8
46	1	Y	C	700-750	9	D	C	1100-1300	4-5
	2	SC	C	500	9-11	P	C	1050-1150	10-12
	3	SC	G	500	6	P	C	1100	6
47	1	Y	C	600	10	D	C	1250	9
	2	Y	M	700	10	D	G	1050	4
	3	Y	C	600	10	D	C	1000	4-6
48	1	SC	C	350-400	8	P	C-HC	1000-1100	9-11
	2	SC	C	350-400	10-11	D	C-HC	1000-1100	9-10
	3	TYO	C	850-950	9	D	C-HC	1100-1200	12
49	1	TYO	C	1050	8-12	D	HC	1250-1350	1-4
	2	TYO	C	950	8-12	D	HC	1150-1250	1-4
	3	Y	C	700-800	8-12	D	HC	1150-1250	4-7
50	1	SC	C	450	10	D	C	950-1050	9
	2	Y	M-G	650	8-9	D	G	1100	6-7
	3	HC	G-C	425	10	P	C	900-1000	9
51	1	SC	G-C	375	9	P	C	1000	8
	2	SC	G-C	375	9	D	HC	900- 950	6
	3	Y	M	550-650	10	D	G-C	1000-1100	5-6

Table 24. (Continued)

Farmer number:	Considered alternative number:	Buying specifications: Age type	Quality	Weight in lb.	Month(s)	Feed program	Selling specifications: Quality	Weight in lb.	Month(s)
52	1	TYO	C	950	8-9	D	C-P	1250-1350	1-2
	2	Y	C	700-750	10	D	C-P	1100-1200	7
	3	SC	C	400	10-11	D	C-P	1050-1150	11-12
53	1	SC	G-C	350	11	D	C	1000-1100	9
	2	SC	G-C	350	10	P	C	1000-1100	11
	3	Y	G-C	600-700	12	D	C	1100	7-8
54	1	SC	C	475	10	D	C	1000	10
	2	Y	G-C	750-800	10	D	G	1200	7
	3	Y	M	600	8	D	C	900	1
55	1	TYO	C	950	9	D	C	1250-1350	2
	2	Y	C	700-750	10	D	C	1100-1300	6-7
	3	SC	C	400-500	10	D	C	1100-1250	9-11
56	1	SC	C	425	10-11	P	C	1050-1100	9-10
	2	Y	G	600-650	11-12	P	C	1100-1150	5-6
	3	TYO	G	975	9	D	C	1200-1300	1-2
57	1	Y	C	600	8-9	D	C-P	950-1050	3-4
	2	Y	C	700	8-9	D	C-P	1050-1150	7-8
	3	SC	C	450	10-11	P	C-P	1000-1200	10-11
58	1	Y	G-C	700	11	D	C	1200	6-8
	2	SC	C	425	10	D	C	1050	8-10
	3	HC	C	400	10	D	C	925	5-6
59	1	Y	C	650-750	9-12	D	C	1000	6-7
	2	Y	C	600	9-12	D	C	1100	6-9
	3	SC	C	500	9-12	D	C	1050-1150	6-9

Table 24. (Continued)

Farmer number:	Considered alternative number:	Buying specifications: Age type	Buying specifications: Quality	Buying specifications: Weight in lb.	Buying specifications: Month(s)	Feed program	Selling specifications: Quality	Selling specifications: Weight in lb.	Selling specifications: Month(s)
59	4	SC	G	500	9-12	D	C	1000-1100	7-10
60	1	Y	C	725	10	D	C	1200-1300	5
	2	Y	C	725	11	D	C	1200-1300	6
	3	SC	C	400	10	D	C	1000	10
	4	SC	C	400	11	D	C	1000	10
61	1	Y	C	600-800	10-11	D	P	1200-1250	7-8
	2	SC	C	400-500	10-12	D	P	1200-1250	12-2
	3	SC	C	400-500	10-12	P	P	1200-1250	1-3
	4	HC	C	400	10-12	D	C-P	850- 900	7-9
62	1	Y	HC	700	9-11	D	C-P	1200-1300	6-8
	2	Y	LC	700	9-11	D	C	1000-1100	3-5
	3	HC	C	450	9-11	P	HC	950	9-11
	4	SC	C	450	9-11	D	HC	1100-1200	10-12
63	1	TYO	G	900	8	D	C	1250	1-2
	2	SC	G	400	10	D	C	1100	10-11
	3	HC	G	400	10	D	C	850	6-7
	4	Y	G-C	750	9	D	C	1050	5
64	1	TYO	C	1000	8	D	C	1300-1400	12
	2	Y	C	750	9	D	C	1100-1200	3
	3	Y	C	750	9	D	C	1200-1300	6-8
	4	Y	M	650	8	D	C	925	12
65	1	SC	G-C	400	7	P	C	1000-1250	8-10
	2	SC	G-C	400	9	P	C	1000-1250	10-12
	3	Y	G-C	600	7	P	C	1050-1250	5-7
	4	Y	G-C	600	9	P	C	1050-1250	7-9

Table 24. (Continued)

Farmer number:	Considered alternative number:	Buying specifications Age type	Quality	Weight in lb.	Month(s)	Feed program	Selling specifications Quality	Weight in lb.	Month(s)
66	1	Y	M	675	10	D	C	1100	6
	2	SC	C	500	10	P	C	1050-1150	9
	3	Y	M	675	10	D	C	1100	4
	4	SC	C	400	9	P	C	1000-1050	10
67	1	Y	C	650	9	P	C-HC	1100-1200	7-9
	2	Y	C	650	10	P	C-HC	1100-1200	8-10
	3	Y	G	650	9	P	C-HC	1100-1200	7-9
	4	Y	G	650	10	P	C-HC	1100-1200	8-10
	5	TYO	G-C	900	9	D	HC	1300	3
68	1	Y	M	600	11	D	G	950	4
	2	Y	G	550-650	7	D	G	1050	1-3
	3	Y	G	550-650	12	D	G	1050	6-8
	4	Y	G	600	12	P	G	1000	6
	5	Y	M	600	7	P	G	1000	1
69	1	SC	G-C	450	9-10	P	LC	1050-1200	9-10
	2	TYO	G-C	950	9-10	D	LC	1200-1300	4-5
	3	Y	G-C	650	9	P	LC	1050-1150	6
	4	TYO	G-C	950	9-10	P	LC	1300-1400	2-3
	5	HC	G-C	450	9-11	P	LC	850- 950	6-7
70	1	Y	M	500-600	10	D	G	900	4
	2	SC	C	400-500	11	D	HC	950-1050	9
	3	SC	C	475	12	P	C	1050-1150	11-12
	4	HC	C	400	12	P	C	900-1050	11
	5	SC	C	350-450	12	P	C	1050-1150	12
71	1	Y	G	800	10	D	C	1150-1250	4
	2	SC	C	450	8	D	C	1050	6

Table 24. (Continued)

Farmer number:	Considered alternative number:	Buying specifications Age type	Quality	Weight in lb.	Month(s)	Feed program	Selling specifications Quality	Weight in lb.	Month(s)
71	3	SC	C	450	10	D	C	1050	10-11
	4	SC	C	450	12	P	C	1050	10-11
	5	TYO	G	750-800	12	D	LC	1200-1250	6-7
72	1	SC	P	500	10-11	P	C-P	1100	9-10
	2	SC	G	500	10-11	D	C-P	1100	9-10
	3	Y	C	700	12	D	C-P	1200-1300	7
	4	Y	C	700	12	P	C-P	1200-1300	9-10
	5	Y	C	700-800	10	D	C-P	1200-1300	5
73	1	TYO	C	925	9-11	D	C	1200-1300	3-5
	2	TYO	G	925	9-11	D	G	1200-1300	3-5
	3	Y	C	650	8	P	C	1150-1250	5-7
	4	Y	C	650	8	D	C	1150-1250	4
	5	Y	C	650	11	D	C	1150-1250	7
	6	SC	C	400-450	9-11	P	C	1150-1250	11-1
	7	HC	C	400	9-11	P	C	900-1000	9-11
74	1	TYO	G-C	900	8-9	D	C	1100-1300	12-1
	2	Y	G-C	700	10	D	C-P	1200-1250	6-8
	3	SC	C	400	10	D	C-P	1100	10
	4	SC	C	400	10	P	C	1000	11-12
	5	SC	C	400	10	P	C-P	1100	11-12
	6	SC	C	400	10	D	C-P	1100-1200	1-2
	7	SC	C	400	10	D	C	1200-1300	1-3
75	1	Y	C	650	10	D	C	1000-1100	6-8
	2	Y	M	650	10	D	G	1000-1100	4-6
	3	Y	C	550	10	D	C	900-1000	7
	4	Y	M	550	10	D	G	850- 950	5
	5	SC	C	420	11	P	C	1050-1150	11

Table 24. (Continued)

Farmer number:	Considered alternative number:	Buying specifications				Feed program	Selling specifications		
		Age type	Quality	Weight in lb.	Month(s)		Quality	Weight in lb.	Month(s)
75	6	SC	M	420	11	P	G	900-1000	8
	7	HC	C	420	11	P	C	850- 950	8
	8	HC	M	420	11	P	G	750- 850	6-7
76[b]	1	SC	C	450	11	D	C	1250	12
	2	Y	C	750	9-10	D	C	1400	6-7
77[b]	1	SC	C	750	11	P	C	1000-1100	11-12
	2	Y	C	400	12	D	C	1000-1100	6

[b]This is one of the two farmers who could not conceptualize the practical decision problems in the desired way.

XIV. APPENDIX D: EXPECTED PRICES AND PRODUCTION COSTS RELEVANT TO EACH CONSIDERED FEEDER CATTLE PROGRAM

The expected purchase cost of feeder cattle, estimated production cost of fat cattle and expected selling price of fat cattle for each possible state of Nature in the practical decision problems are shown in Table 25 for each farmer's considered alternatives.

Table 25. Expected purchase cost of feeder cattle, estimated production cost of fat cattle and expected selling price of fat cattle under each state S_j for each considered alternative in the practical decision problems[a]

Farmer number:	Considered alter-native number	Expected purchase cost per lb. of initial liveweight				Estimated production cost per lb. of final liveweight				Expected selling price per lb. of final liveweight			
		S_1^b	S_2^c	S_3^d	S_4^e	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
1	1	18.0	18.0	16.0	16.0	18.71	18.71	18.20	18.20	22.0	23.0	19.0	20.0
2	1	20.0	20.0	20.0	20.0	20.19	20.19	21.30	21.30	23.0	22.0	23.0	22.0
3	1	19.0	19.0	17.0	17.0	19.53	19.53	19.47	19.47	22.5	20.5	26.0	22.0
4	1	20.0	20.0	15.0	22.0	19.44	19.44	17.19	21.49	24.0	24.0	20.0	27.0
5	1	20.0	20.0	17.5	17.5	18.95	18.95	18.12	18.12	25.0	23.0	27.0	25.0
6	1	20.5	20.5	20.5	20.5	20.21	20.21	21.34	21.34	27.5	26.0	27.5	26.0
7	1	25.0	25.0	23.5	23.5	20.39	20.39	20.83	20.83	26.5	28.5	25.0	27.0
8	1	20.0	20.0	18.0	18.0	18.73	18.73	18.72	18.72	24.0	22.0	25.0	23.0

[a]No data are presented for those two farmers, numbers 76 and 77, who could not conceptualize the practical decision problems in the desired way. All costs are expressed in cents.

[b]Good cropping weather, marketings mainly March to June.

[c]Good cropping weather, marketings mainly June to September.

[d]Poor cropping weather, marketings mainly March to June.

[e]Poor cropping weather, marketings mainly June to September.

Table 25. (Continued)

Farmer number:	Considered alter-native number:	Expected purchase cost per lb. of initial liveweight				Estimated production cost per lb. of final liveweight				Expected selling price per lb. of final liveweight			
		S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
9	1	20.0	20.0	17.5	17.5	19.11	19.11	18.67	18.67	19.0	22.0	19.0	21.0
10	1	20.0	20.0	18.0	18.0	19.19	19.19	19.01	19.01	24.0	24.0	24.0	24.0
11	1	22.5	22.5	21.0	21.0	19.65	19.65	19.96	19.96	26.0	24.5	27.0	26.0
12	1	22.5	22.5	20.0	20.0	19.22	19.22	19.32	19.32	25.0	23.0	23.0	23.0
13	1	22.0	22.0	18.5	18.5	21.23	21.23	20.01	20.01	23.0	26.0	20.0	22.0
14	1	24.0	24.0	23.0	23.0	21.62	21.62	21.86	21.86	25.0	26.0	25.0	26.0
	2	25.0	25.0	23.5	23.5	19.74	19.74	20.11	20.11	27.0	25.0	27.0	25.0
15	1	20.0	20.0	18.0	18.0	19.24	19.24	19.31	19.31	22.0	23.0	20.0	20.5
	2	18.0	18.0	16.0	16.0	18.27	18.27	18.34	18.34	20.0	21.0	18.0	18.5
16	1	16.0	18.0	15.0	18.0	16.55	17.54	17.03	18.52	18.0	22.0	19.0	23.0
	2	16.0	18.0	15.0	18.0	16.77	17.77	17.28	18.77	18.0	22.0	19.0	23.0
17	1	21.0	22.0	21.0	23.0	20.52	21.06	21.63	22.71	25.0	27.0	25.0	30.0
	2	18.0	20.0	20.0	22.0	17.16	18.08	19.02	19.94	21.0	23.0	25.0	27.0
18	1	20.0	20.0	18.0	18.0	19.08	19.08	18.99	18.99	22.0	21.0	21.0	20.0
	2	22.0	22.0	20.0	20.0	21.12	21.12	21.15	21.15	24.5	24.0	23.0	22.0
19	1	21.7	21.7	21.7	21.7	21.77	21.77	22.57	22.57	24.0	24.0	24.0	24.0
	2	25.0	25.0	25.0	25.0	23.41	23.41	24.49	24.49	25.0	25.0	24.0	25.0

Table 25. (Continued)

Farmer number:	Considered alternative number:	Expected purchase cost per lb. of initial liveweight				Estimated production cost per lb. of final liveweight				Expected selling price per lb. of final liveweight			
		S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
20	1	20.0	21.0	19.0	20.0	18.54	18.99	19.06	19.52	22.5	22.0	24.0	22.0
	2	18.0	19.0	18.0	19.0	19.04	19.57	20.16	20.70	22.5	22.0	24.0	22.0
21	1	19.0	18.0	17.0	18.0	19.88	19.22	19.43	20.09	21.5	22.0	20.0	22.0
	2	25.0	25.0	21.5	21.5	21.08	21.08	20.37	20.37	25.0	23.5	23.0	21.5
22	1	18.0	18.0	17.0	17.0	19.07	19.07	19.51	19.51	19.0	20.0	17.0	18.0
	2	20.5	20.5	19.0	19.0	18.36	18.36	18.49	18.49	22.0	23.0	19.5	21.0
23	1	22.5	22.5	20.0	20.0	21.91	21.91	21.15	21.15	23.4	24.0	23.0	25.0
	2	22.0	22.0	21.0	21.0	19.26	19.26	19.70	19.70	23.4	24.0	23.0	25.0
24	1	21.0	20.5	19.7	19.2	20.61	20.31	20.85	20.56	23.5	24.0	23.5	24.0
	2	22.0	21.5	21.0	21.0	19.94	19.68	20.39	20.39	25.0	24.0	25.0	24.0
25	1	19.0	19.0	18.0	18.0	17.63	17.63	17.93	17.93	22.0	21.0	23.0	21.0
	2	18.5	18.5	18.0	18.0	19.17	19.17	19.88	19.88	23.0	22.5	22.5	22.0
26	1	22.0	22.0	21.0	21.0	21.78	21.78	21.87	21.87	26.0	27.0	26.0	27.0
	2	21.0	21.0	21.0	21.0	19.55	19.55	20.53	20.53	24.0	24.0	25.0	26.0
27	1	20.0	20.0	18.0	18.0	18.63	18.63	18.71	18.71	22.5	21.0	22.0	20.0
	2	20.0	20.0	18.0	18.0	18.25	18.25	18.52	18.52	21.0	22.5	20.0	22.0
28	1	21.5	21.5	18.5	18.5	21.02	21.02	20.41	20.41	23.5	21.5	22.0	19.5
	2	25.0	25.0	23.0	23.0	19.62	19.62	19.82	19.82	27.7	24.5	25.0	24.0
29	1	24.0	24.0	23.0	23.0	20.16	20.16	20.74	20.74	29.0	27.0	30.0	27.0
	2	22.0	22.0	21.0	21.0	21.33	21.33	21.69	21.69	27.0	25.0	28.0	26.0

Table 25. (Continued)

Farmer number:	Considered alternative number:	Expected purchase cost per lb. of initial liveweight				Estimated production cost per lb. of final liveweight				Expected selling price per lb. of final liveweight			
		S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
30	1	22.0	22.0	16.0	16.0	20.93	20.93	18.15	18.15	19.0	23.0	15.0	17.0
	2	18.0	18.0	15.0	15.0	18.03	18.03	17.25	17.25	18.0	19.0	16.0	16.0
31	1	20.0	20.0	20.0	20.0	20.02	20.02	21.06	21.06	23.0	22.0	24.0	24.0
	2	17.5	17.5	20.0	20.0	16.24	16.24	18.25	18.25	25.0	22.5	26.5	25.5
32	1	27.5	27.5	25.0	25.0	22.38	22.38	22.14	22.14	26.5	26.5	28.5	27.0
	2	27.5	27.5	25.0	25.0	20.63	20.63	20.58	20.58	26.5	26.5	28.5	27.0
33	1	19.5	19.5	18.5	18.5	20.03	20.03	20.29	20.29	24.5	23.0	20.0	23.0
	2	23.0	23.0	23.0	23.0	18.95	18.95	19.93	19.93	21.0	25.0	21.0	27.5
34	1	22.5	22.5	17.5	17.5	21.19	21.19	19.64	19.64	24.5	24.5	17.5	17.5
	2	24.0	24.0	18.5	18.5	19.73	19.73	18.16	18.16	24.0	22.5	18.5	20.0
35	1	20.0	20.0	17.0	17.0	20.44	20.44	19.14	19.14	23.0	26.0	20.0	23.0
	2	22.0	22.0	20.0	20.0	19.38	19.38	19.56	19.56	25.0	24.0	21.0	22.0
36	1	22.0	22.0	22.0	22.0	18.62	18.62	19.61	19.61	24.0	26.0	24.0	27.5
	2	22.0	22.0	22.0	22.0	19.34	19.34	20.37	20.37	24.0	26.0	24.0	27.5
37	1	20.0	20.0	21.0	21.0	19.26	19.26	20.73	20.73	22.5	23.5	24.5	25.5
	2	18.0	18.0	19.0	19.0	18.65	18.65	19.99	19.99	20.0	21.0	22.0	23.0
38	1	24.0	23.0	20.0	20.0	19.52	19.09	18.79	18.79	27.0	28.0	30.0	30.0
	2	11.0	11.0	11.0	11.0	13.44	13.44	13.95	13.95	14.0	14.0	15.5	15.5
39	1	18.5	18.5	17.5	17.5	17.54	17.54	18.25	18.25	23.25	23.2	24.2	24.2
	2	21.0	21.0	19.5	19.5	20.00	20.00	19.96	19.96	24.0	23.0	25.0	24.0

Table 25. (Continued)

Farmer number:	Considered alternative number:	Expected purchase cost per lb. of initial liveweight				Estimated production cost per lb. of final liveweight				Expected selling price per lb. of final liveweight			
		S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
40	1	21.0	21.0	20.0	20.0	18.29	18.29	18.85	18.84	21.0	23.0	22.5	24.0
	2	19.5	19.5	18.5	18.5	19.42	19.42	19.69	19.69	22.0	23.0	23.0	25.0
41	1	22.0	22.0	21.0	21.0	19.92	19.92	20.46	20.46	22.0	24.0	24.0	26.0
	2	24.0	24.0	22.0	22.0	19.63	19.63	19.59	19.59	24.0	22.0	24.0	26.0
42	1	20.0	20.0	18.0	18.0	21.30	21.30	21.14	21.14	23.0	25.0	25.0	26.0
	2	25.0	25.0	21.0	21.0	19.33	19.33	18.81	18.81	25.0	23.0	26.0	26.0
43	1	23.5	23.5	22.0	22.0	22.99	22.99	22.78	22.78	23.0	25.0	24.0	26.0
	2	22.5	22.5	18.0	18.0	21.21	21.21	19.07	19.07	23.0	23.0	21.0	21.0
44	1	22.5	22.5	22.5	22.5	22.27	22.27	23.12	23.12	22.5	24.5	22.5	24.5
	2	22.5	22.5	22.5	22.5	21.17	21.17	22.11	22.11	25.0	24.5	26.0	25.5
45	1	20.0	20.0	18.0	18.0	19.08	19.08	18.99	18.99	23.0	20.0	21.5	19.0
	2	22.0	22.0	20.0	20.0	20.09	20.09	20.00	20.00	23.0	22.0	23.0	21.0
	3	22.0	22.0	21.0	21.0	19.35	19.35	19.72	19.72	24.0	23.0	23.0	24.0
46	1	23.0	23.0	19.0	19.0	22.55	22.55	20.79	20.79	23.0	28.0	21.0	24.0
	2	25.5	25.5	22.5	22.5	21.20	21.20	20.54	20.54	26.0	25.5	23.0	25.5
	3	22.5	22.5	18.0	18.0	19.62	19.62	18.20	18.20	21.5	22.5	17.0	18.0
47	1	22.0	22.0	20.0	20.0	21.07	21.07	21.18	21.18	25.0	24.0	23.0	22.0
	2	18.0	18.0	16.0	16.0	19.63	19.63	19.01	19.01	21.0	18.0	19.0	16.0
	3	20.0	20.0	18.0	18.0	20.22	20.22	19.82	19.82	23.0	23.0	21.0	21.0
48	1	18.0	18.0	20.5	20.5	16.69	16.69	18.73	18.73	23.0	22.0	24.5	23.5
	2	18.5	18.5	17.2	17.2	17.57	17.57	18.15	18.15	24.2	23.2	24.7	23.7

Table 25. (Continued)

Farmer number:	Considered alter-native number:	Expected purchase cost per lb. of initial liveweight				Estimated production cost per lb. of final liveweight				Expected selling price per lb. of final liveweight			
		S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
48	3	20.5	20.5	18.5	18.5	21.83	21.83	20.82	20.82	23.7	24.7	24.5	23.5
49	1	23.5	23.5	22.5	22.5	25.15	25.15	25.02	25.02	28.0	26.0	22.5	24.5
	2	23.0	23.0	21.0	21.0	24.09	24.09	23.05	23.05	27.0	25.0	21.0	21.0
	3	22.0	22.0	20.0	20.0	23.17	23.17	22.83	22.83	27.0	25.0	20.0	20.0
50	1	25.0	25.0	23.0	23.0	21.54	21.54	21.46	21.46	27.0	27.0	28.0	28.0
	2	25.0	25.0	23.0	23.0	23.57	23.57	23.20	23.20	27.0	27.0	28.0	28.0
	3	21.5	21.5	21.5	21.5	19.44	19.44	20.40	20.40	23.5	22.5	23.5	22.5
51	1	18.0	18.0	16.5	16.5	17.57	17.57	17.99	17.99	23.5	22.0	20.5	18.7
	2	18.0	18.0	16.5	16.5	17.79	17.79	18.11	18.11	19.5	22.0	24.0	22.0
	3	16.5	16.5	14.0	14.0	18.35	18.35	17.78	17.78	18.0	20.0	16.0	21.0
52	1	22.2	22.2	19.5	19.5	23.55	23.55	22.02	22.02	25.0	27.0	25.0	27.0
	2	22.0	22.0	20.0	20.0	22.20	22.20	21.71	21.71	25.0	25.0	25.0	23.0
	3	25.0	25.0	21.0	21.0	20.55	20.55	19.92	19.92	30.0	30.0	28.0	28.0
53	1	20.0	20.0	19.0	19.0	18.15	18.15	18.90	18.90	25.0	23.0	25.0	23.0
	2	21.0	21.0	20.0	20.0	17.45	17.45	18.10	18.10	25.0	23.0	25.0	23.0
	3	19.0	19.0	18.0	18.0	19.60	19.60	19.88	19.88	23.0	24.0	23.0	24.0
54	1	24.0	24.0	22.0	22.0	21.34	21.34	21.15	21.15	25.0	22.0	24.0	22.0
	2	23.0	23.0	20.0	20.0	24.13	24.13	22.97	22.97	24.0	21.0	24.0	23.0
	3	20.0	20.0	16.0	16.0	19.84	19.84	17.65	17.65	23.0	23.0	22.0	19.0
55	1	23.0	23.0	20.0	20.0	24.05	24.05	22.54	22.54	26.0	26.0	26.0	26.0
	2	23.0	23.0	20.0	20.0	22.33	22.33	21.29	21.29	29.0	29.0	29.0	29.0
	3	26.0	26.0	23.0	23.0	21.07	21.07	20.82	20.82	28.0	28.0	28.0	28.0

Table 25. (Continued)

Farmer number:	Considered alternative number:	Expected purchase cost per lb. of initial liveweight				Estimated production cost per lb. of final liveweight				Expected selling price per lb. of final liveweight			
		S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
56	1	20.0	20.0	23.0	23.0	17.80	17.80	20.09	20.09	25.0	25.0	25.0	25.0
	2	18.5	18.5	18.0	18.0	18.56	18.56	19.08	19.08	21.7	21.7	23.0	23.0
	3	20.0	20.0	18.0	18.0	22.04	22.04	21.07	21.07	23.0	23.0	23.0	23.0
57	1	21.0	21.0	21.0	21.0	21.17	21.17	22.05	22.05	21.0	23.5	22.0	24.0
	2	20.0	20.0	21.0	21.0	20.78	20.78	22.31	22.31	23.0	24.0	24.0	23.0
	3	24.0	24.0	25.0	24.0	19.77	19.77	21.17	19.77	26.0	26.0	27.0	26.0
58	1	21.0	21.0	19.0	19.0	20.72	20.72	20.39	20.39	22.0	23.0	22.0	23.0
	2	22.0	22.0	20.0	20.0	19.50	19.50	19.59	19.59	25.0	25.0	26.0	26.0
	3	19.0	19.0	17.0	17.0	17.89	17.89	17.96	17.96	24.0	24.0	24.0	24.0
59	1	23.5	23.5	21.5	21.5	23.95	23.95	23.15	23.15	23.5	24.5	25.0	23.0
	2	24.0	24.0	18.0	18.0	22.26	22.26	20.13	20.13	23.0	23.0	22.5	25.0
	3	25.0	25.0	20.0	20.0	21.80	21.80	19.61	19.61	23.0	24.0	22.5	23.0
	4	23.0	23.0	18.0	18.0	20.80	20.80	18.70	18.70	23.0	23.5	22.5	23.0
60	1	20.0	20.0	19.0	19.0	20.06	20.06	20.37	20.37	22.0	24.0	22.0	23.0
	2	20.0	20.0	19.0	19.0	20.06	20.06	20.37	20.37	21.5	23.5	21.5	22.5
	3	23.0	23.0	22.0	22.0	20.00	20.00	20.56	20.56	23.0	24.0	24.0	25.0
	4	22.5	22.5	21.5	21.5	19.73	19.73	20.29	20.29	22.5	23.5	23.5	24.5
61	1	20.0	20.0	18.5	18.5	20.65	20.65	20.59	20.59	25.0	21.0	23.5	21.0
	2	23.0	23.0	21.0	21.0	19.82	19.82	20.02	20.02	27.0	27.0	27.0	27.0
	3	23.0	23.0	21.0	21.0	19.08	19.08	18.98	18.98	27.0	27.0	27.0	27.0
	4	20.0	20.0	17.5	17.5	18.66	18.66	18.38	18.38	23.0	21.5	24.0	23.0
62	1	20.0	20.0	18.0	18.0	20.16	20.16	19.93	19.93	23.0	20.0	25.5	23.0
	2	18.0	18.0	16.0	16.0	19.05	19.05	18.38	18.38	20.0	17.0	22.5	20.0

Table 25. (Continued)

Farmer number:	Considered alternative number:	Expected purchase cost per lb. of initial liveweight				Estimated production cost per lb. of final liveweight				Expected selling price per lb. of final liveweight			
		S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
62	3	21.0	21.0	20.0	20.0	19.18	19.18	19.79	19.79	25.0	22.0	24.0	21.0
	4	23.0	23.0	22.0	22.0	18.81	18.81	19.38	19.38	27.0	25.0	26.0	23.0
63	1	20.0	20.0	18.0	18.0	21.62	21.62	20.90	20.90	25.0	26.0	22.0	22.0
	2	23.0	23.0	21.0	21.0	19.55	19.55	19.79	19.79	28.0	28.0	26.0	26.0
	3	20.0	20.0	18.0	18.0	18.88	18.88	18.81	18.81	24.0	24.0	20.0	20.0
	4	22.0	22.0	21.0	21.0	22.32	22.32	22.18	22.18	25.0	25.0	26.0	26.0
64	1	22.0	22.0	19.5	19.5	23.24	23.24	22.07	22.07	24.5	24.5	24.5	24.5
	2	22.0	22.0	20.0	20.0	21.44	21.44	21.06	21.06	23.0	23.0	24.0	24.5
	3	22.0	22.0	20.0	20.0	21.70	21.70	21.30	21.30	26.5	24.0	27.0	24.0
	4	20.0	20.0	17.5	17.5	21.10	21.10	20.97	20.97	23.0	23.0	23.0	23.0
65	1	22.5	22.5	22.5	22.5	18.44	18.44	19.47	19.47	25.5	25.5	25.5	25.5
	2	24.0	24.0	24.0	24.0	19.05	19.05	20.08	20.08	27.0	27.0	27.0	27.0
	3	21.0	21.0	21.0	21.0	20.25	20.25	21.10	21.10	24.0	24.0	24.0	24.0
	4	22.0	22.0	22.0	22.0	20.84	20.84	21.69	21.69	25.0	25.0	25.0	25.0
66	1	20.0	20.0	19.7	19.7	21.02	21.02	21.02	21.02	21.5	22.0	22.5	23.0
	2	21.5	21.5	21.0	21.0	19.16	19.16	19.80	19.80	26.5	25.0	27.0	26.0
	3	20.0	20.0	19.7	19.7	20.20	20.20	20.20	20.20	22.0	22.5	23.0	23.5
	4	22.0	22.0	21.5	21.5	18.88	18.88	19.61	19.61	25.0	24.0	26.0	25.5
67	1	20.5	20.5	19.5	19.5	20.02	20.02	20.26	20.26	24.5	22.5	25.5	24.5
	2	20.0	20.0	19.0	19.0	19.72	19.72	19.96	19.96	25.0	22.5	25.5	24.5
	3	19.0	19.0	18.5	18.5	18.81	18.81	19.29	19.29	24.5	22.0	24.5	24.0
	4	18.5	18.5	18.0	18.0	18.50	18.50	18.99	18.99	24.5	22.0	24.5	24.0
	5	17.7	17.7	17.0	17.0	19.92	19.92	20.25	20.25	19.5	21.5	22.0	24.0

Table 25. (Continued)

Farmer number:	Considered alternative number:	Expected purchase cost per lb. of initial liveweight				Estimated production cost per lb. of final liveweight				Expected selling price per lb. of final liveweight			
		S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
68	1	16.0	15.0	16.5	16.0	18.30	17.63	19.51	19.18	20.0	20.0	21.0	21.0
	2	20.5	20.5	22.0	22.0	20.46	20.46	22.32	22.32	22.0	22.0	22.5	22.5
	3	20.0	20.0	21.0	21.0	20.15	20.15	21.71	21.71	22.0	22.0	23.0	23.0
	4	16.0	16.0	17.0	17.0	18.47	18.47	20.07	20.07	19.0	19.0	21.0	21.0
	5	16.5	16.5	17.5	17.5	18.79	18.79	20.38	20.38	17.5	17.5	18.5	18.5
69	1	23.5	23.5	20.0	20.0	18.26	18.26	17.40	17.40	26.0	24.0	27.0	25.0
	2	19.0	19.0	19.0	19.0	21.59	21.59	21.59	21.59	21.0	23.0	22.0	25.0
	3	20.0	20.0	18.0	18.0	19.31	19.31	18.61	18.61	24.0	23.0	24.0	25.0
	4	19.0	19.0	19.0	19.0	20.76	20.76	20.76	20.76	22.5	22.5	24.0	24.0
	5	21.5	21.5	16.0	16.0	20.60	20.60	18.22	18.22	23.5	22.5	24.0	23.0
70	1	19.0	18.0	19.0	18.0	20.39	19.73	21.30	20.65	22.0	23.0	22.0	23.0
	2	22.0	22.0	21.5	21.5	19.99	19.99	20.66	20.66	23.0	25.0	25.0	26.0
	3	21.0	21.0	20.5	20.5	18.52	18.52	19.19	19.19	23.0	23.0	23.0	23.0
	4	18.0	18.0	17.5	17.5	17.64	17.64	18.45	18.45	21.0	21.0	21.0	21.0
	5	23.0	23.0	22.5	22.5	18.68	18.68	19.49	19.49	23.0	23.0	23.0	23.0
71	1	18.0	18.0	16.0	16.0	20.19	20.19	19.73	19.73	22.5	23.0	22.5	23.0
	2	24.0	24.0	22.0	22.0	20.67	20.67	20.67	20.67	24.0	24.0	25.0	25.0
	3	23.0	23.0	21.0	21.0	19.60	19.60	19.56	19.56	24.0	25.0	24.0	25.0
	4	24.0	24.0	24.0	24.0	19.74	19.74	20.64	20.64	25.0	25.0	25.0	25.0
	5	20.0	20.0	20.0	20.0	21.62	21.62	22.69	22.69	23.0	23.0	23.0	23.0
72	1	25.0	22.0	21.0	21.0	21.01	21.01	20.38	20.38	25.0	25.0	25.0	24.0
	2	24.0	20.0	20.0	20.0	21.15	21.15	20.05	20.05	24.0	23.0	24.0	23.0
	3	22.0	22.0	22.0	22.0	21.24	21.24	22.22	22.22	25.0	25.0	25.0	24.0
	4	22.0	22.0	22.0	22.0	20.56	20.56	21.35	21.35	25.0	24.0	25.0	24.0
	5	22.0	22.0	22.0	22.0	21.82	21.82	22.63	22.63	23.0	24.0	23.0	24.0

Table 25. (Continued)

Farmer number:	Considered alternative number:	Expected purchase cost per lb. of initial liveweight				Estimated production cost per lb. of final liveweight				Expected selling price per lb. of final liveweight			
		S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
73	1	23.0	23.0	20.0	20.0	24.87	24.87	23.29	23.29	23.0	25.0	23.0	26.0
	2	19.0	19.0	16.0	16.0	21.67	21.67	20.09	20.09	21.0	22.0	22.0	23.0
	3	22.0	22.0	21.0	21.0	20.72	20.72	21.00	21.00	24.0	24.0	25.0	25.0
	4	22.0	22.0	21.0	21.0	20.99	20.99	21.40	21.40	24.5	24.0	25.0	25.5
	5	21.0	21.0	20.0	20.0	20.41	20.41	20.82	20.82	25.0	24.0	26.0	24.5
	6	23.0	23.0	21.5	21.5	18.94	18.94	19.41	19.41	25.0	24.0	26.0	25.5
	7	21.0	21.0	19.0	19.0	19.28	19.28	19.37	19.37	23.0	22.5	24.5	24.0
74	1	22.0	22.0	20.0	20.0	23.05	23.05	22.19	22.19	24.0	24.0	26.0	26.0
	2	22.0	22.0	20.0	20.0	21.37	21.37	21.09	21.09	26.0	26.5	26.0	27.0
	3	22.0	22.0	20.0	20.0	19.16	19.16	19.40	19.40	26.0	28.0	26.0	28.0
	4	22.0	22.0	20.0	20.0	18.98	18.98	19.04	19.04	24.0	26.0	24.5	26.5
	5	22.0	22.0	20.0	20.0	16.77	16.77	16.77	16.77	24.0	26.0	24.5	26.0
	6	22.0	22.0	20.0	20.0	20.30	20.30	20.92	20.92	26.0	28.0	26.0	28.0
	7	22.0	22.0	20.0	20.0	20.67	20.67	21.32	21.32	24.0	24.0	26.0	26.0
75	1	20.0	20.0	18.5	18.5	20.52	20.52	20.38	20.38	23.5	22.0	25.0	22.5
	2	18.0	18.0	16.0	16.0	19.74	19.74	19.20	19.20	20.0	21.0	22.5	21.5
	3	20.0	20.0	17.0	17.0	20.42	20.42	19.50	19.50	23.0	22.5	22.0	20.5
	4	18.0	18.0	16.5	16.5	19.80	19.80	19.76	19.76	21.0	20.2	20.5	19.5
	5	23.0	23.0	21.0	21.0	19.60	19.60	19.83	19.83	25.5	24.0	27.0	23.5
	6	17.0	17.0	16.5	16.5	16.51	16.51	17.13	17.13	21.5	20.0	22.0	20.0
	7	18.5	18.5	17.5	17.5	17.73	17.73	18.12	18.12	21.5	23.0	18.5	22.0
	8	17.5	17.5	17.0	17.0	17.60	17.60	18.13	18.13	20.0	22.0	19.0	21.0

XV. APPENDIX E: DERIVATION OF NORMATIVE PAYOFF MATRICES FOR THE PRACTICAL DECISION PROBLEMS

As pointed out in Chapter VII, rational analysis of the decision problem necessitates that the elements of the payoff matrix be comparable. This was achieved by using as payoff elements the annual per cent net return expected from each of the considered feeder program alternatives under each possible state of Nature. These per cent returns were calculated for each farmer as follows.

Denote by:

a_{ij} : the expected annual per cent net return on investment in alternative A_i° if the state of Nature S_j should prevail.

p_{ij} : the farmer's expected selling price at the farm in cents per pound liveweight of fat cattle from A_i° if S_j occurs.

c_{ij} : the estimated cost of production in cents per pound liveweight of fat cattle from A_i° if S_j occurs. The method of calculating these production costs is shown in Appendix F.

e_i : the farmer's proportionate equity in the capital invested in A_i° if A_i° is selected. This figure could not be ascertained precisely. As an approximation, the farmer's estimate of his year to year to year average equity ratio for his feeder cattle enterprise was used.

r : the maximum annual per cent net return the farmer felt certain of receiving from alternative investment of his feeder enterprise capital during the period of the year when it is free for investment elsewhere.

s : the proportion of the farmer's equity in his feeder enterprise capital that he normally invests elsewhere when it is not invested in feeder cattle.

t_i : the fraction of the year during which the farmer's feeder enterprise capital is free for investment elsewhere.

m_i : the length of feeder program A_i° in months.

The payoff elements were then calculated for each farmer by the following formulae:

$$(7) \quad a_{ij} = \frac{p_{ij} - c_{ij}}{c_{ij}} \cdot \frac{12}{m_i} \cdot \frac{100}{1} \qquad \text{if } m_i \geqslant 12,$$

$$(8) \quad a_{ij} = \frac{p_{ij} - c_{ij} + c_{ij}e_i r s t_i}{c_{ij}} \cdot \frac{100}{1} \qquad \text{if } m_i < 12.$$

While reinvestment of the farmer's personal capital in the off-feeder season was common, only one farmer reinvested borrowed capital. The net return from this investment was included in the calculation of his payoff matrix.

The above formulae assume that the feeder enterprise capital is invested in full at the start of the feeder program. In practice, this is not the case. The major part of the investment occurs when the feeders are bought, the remainder accumulating over the period of the program as feed and other services are expended on the cattle. To take account of the exact sequence and rate of this accumulation would not be feasible. It would also be unrealistic in so far as many of the farmers kept capital aside to cover their feeder enterprise. Overall, the assumption of a lump-sum investment makes the percentage returns slightly less than exact estimation (if it were possible) would show them to be. However, the ranking of payoffs both within and between alternatives would probably not be changed since the rate of capital accumulation over the feeding season is approximately equal for each type of feeder cattle program after the initial purchase outlay has been made.

XVI. APPENDIX F: DERIVATION OF PRODUCTION COST PER POUND LIVEWEIGHT OF FAT CATTLE

The cost of producing fat cattle under each alternative feeder program for each possible state of Nature in the practical decision problems was calculated by the following procedure:

			Costs
Feeders at farm	____lb.	at $________ per hundred	$______
Corn	____bu.	at $________ per bushel	$______
Corn silage	____tons	at $________ per ton	$______
Hay	____tons	at $16 per ton	$______
Pasture	____days	at 10 cents per day	$______
Supplement	____lb.	at 4 cents per lb.	$______
Hired labor	____hours	at $________ per hour	$______
Salt and mineral per head			$1.00
Veterinary and medical expenses per head			$2.00
Miscellaneous expense including death loss			
Calves: 6% of cost of feeders			$______
Others: 3% of cost of feeders			$______
Interest			
Cost of feeder x 0.5% x number of months on farm			$______
Total cost of fat animal			$______

Selling weight _______lb.

Cost of production:

(total cost ÷ selling weight) x 100. ____cents per lb.

When a reasonable knowledge of the feed requirements was evident, the quantities of the various feeds nominated by the farmer were used in making these calculations. Otherwise the quantities used were those published by the Iowa State College Agricultural Extension Service (37). For the few cases where grain or silage other than corn was used, a conversion to corn or corn silage equivalents was made using Morrison's "all analyses" feed evaluation factors for corn (54, pp. 1135-1142).

The feeder cattle buying prices used were those expected by the farmer under each of Nature's possible states. Corn prices also varied over Nature's states, as outlined in Chapter VIII. Silage was valued on an opportunity cost basis in terms of corn; hence the cost of silage also varied over the possible states of Nature. Opportunity cost was used because actual costs were unavailable.

The only labor costs included were those for hired labor, their being no rational basis for costing the owner-operator's labor. This follows normal farm management accounting procedures. Only ten farmers used hired labor, including family labor paid on a wage basis. For these farmers the actual wage rate being paid was used. The labor requirements used in calculating labor cost were those tabulated by the Department of Economics and Sociology of Iowa State College (39).

XVII. APPENDIX G: NORMATIVE PAYOFF MATRICES FOR THE PRACTICAL DECISION PROBLEMS

Table 26 lists the normative payoff matrices for the practical decision problems. As explained in Chapter VII, to make the matrix elements comparable they are expressed as the expected annual per cent net return on investment forthcoming from each considered feeder cattle program for each possible state of Nature.

Table 26. Expected annual per cent net return on investment for each considered feeder program under each possible state of Nature S_j in the practical decision problems

Farmer number:	Considered alternative number:	Expected annual per cent net return S_1^a	S_2^b	S_3^c	S_4^d
1	1	17.6	22.9	4.4	9.9
2	1	13.9	9.0	8.0	3.3
3	1	15.2	5.0	33.5	13.0
4	1	25.5	25.5	18.3	27.6
5	1	32.1	21.5	49.2	38.1
6	1	36.7	29.2	29.4	22.4
7	1	27.7	36.7	18.5	27.3
8	1	28.1	17.5	33.5	22.9
9	1	-0.6	15.1	1.8	-12.5
10	1	25.9	25.9	27.1	27.1
11	1	32 6	24.9	35.5	30.5
12	1	30.1	19.7	19.0	19.0
13	1	10.6	24.8	2.2	12.2
14	1	15.6	20.3	14.4	18.9
	2	36.8	26.6	34.3	24.3
15	1	14.3	19.5	3.6	6.2
	2	9.5	14.9	-1.8	0.9

[a]Good cropping weather, marketings mainly March to June.

[b]Good cropping weather, marketings mainly June to September.

[c]Poor cropping weather, marketings mainly March to June.

[d]Poor cropping weather, marketings mainly June to September.

Table 26. (Continued)

Farmer number:	Considered alternative number:	Expected annual per cent net return			
		S_1	S_2	S_3	S_4
16	1	8.8	25.4	11.6	24.2
	2	7.3	23.8	9.9	22.5
17	1	22.4	28.8	16.2	32.7
	2	20.7	25.1	29.0	32.7
18	1	15.3	10.1	10.6	5.3
	2	16.0	13.6	8.7	4.0
19	1	10.2	10.2	6.3	6.3
	2	6.8	6.8	-2.0	2.1
20	1	21.9	16.4	26.4	13.3
	2	19.0	13.2	19.8	7.1
21	1	8.1	14.5	2.9	9.5
	2	18.6	11.5	12.9	5.5
22	1	-0.4	4.9	-12.9	-7.7
	2	19.8	25.3	5.5	13.6
23	1	7.7	10.4	9.7	19.1
	2	21.7	24.8	16.9	27.1
24	1	14.5	18.6	13.1	17.2
	2	25.7	22.3	22.9	18.0
25	1	24.8	19.1	28.3	17.1
	2	20.0	17.4	13.2	10.7
26	1	21.4	26.0	20.9	25.5
	2	24.0	24.0	23.0	27.9
27	1	21.3	13.2	18.1	7.3
	2	13.9	21.5	7.4	17.3
28	1	11.8	2.3	7.8	-4.5
	2	34.3	20.6	21.6	17.5
29	1	43.8	33.9	44.6	30.2
	2	26.6	17.2	29.1	19.9
30	1	-8.0	11.1	-16.1	-5.1
	2	1.7	7.3	-5.3	-5.3

Table 26. (Continued)

Farmer number:	Considered alternative number:	Expected annual per cent net return S_1	S_2	S_3	S_4
31	1	14.9	9.9	14.0	14.0
	2	46.2	33.1	38.7	34.0
32	1	18.7	18.7	28.9	22.2
	2	28.4	28.4	38.5	31.2
33	1	22.5	15.0	-1.2	13.5
	2	10.9	32.0	5.5	38.1
34	1	17.1	17.1	-9.4	-9.4
	2	21.9	14.3	2.1	10.4
35	1	13.0	27.6	4.9	20.6
	2	29.1	23.9	7.5	12.6
36	1	26.7	36.6	20.6	37.1
	2	24.1	34.4	17.8	35.0
37	1	4.7	9.9	6.9	11.8
	2	22.2	27.6	24.2	29.2
38	1	32.8	40.0	51.1	51.1
	2	4.4	4.4	11.3	11.3
39	1	33.1	33.1	33.4	33.4
	2	20.6	15.6	25.8	20.8
40	1	11.5	20.0	15.0	21.2
	2	13.3	18.4	16.8	27.0
41	1	10.4	20.5	17.3	27.1
	2	22.3	12.1	22.5	32.7
42	1	8.0	17.5	18.3	23.0
	2	27.0	17.5	35.3	35.3
43	1	1.5	10.2	6.8	15.6
	2	12.8	12.8	14.5	14.5
44	1	1.0	10.0	-2.7	6.0
	2	18.1	15.7	17.6	15.3
45	1	20.5	4.8	13.2	0.0
	2	14.5	9.5	15.0	5.0

Table 26. (Continued)

Farmer number:	Considered alternative number:	Expected annual per cent net return			
		S_1	S_2	S_3	S_4
45	3	22.2	17.4	15.4	20.0
46	1	2.5	24.7	1.5	16.0
	2	20.9	18.7	11.0	22.3
	3	9.6	14.7	-6.6	-1.1
47	1	18.6	13.9	8.6	3.9
	2	7.0	-8.3	0.0	-15.8
	3	13.7	13.7	5.9	5.9
48	1	32.4	27.3	26.4	21.8
	2	38.4	32.7	36.8	31.3
	3	12.5	17.1	21.4	16.6
49	1	13.3	5.3	-8.1	-0.1
	2	14.1	5.8	1.9	6.2
	3	17.8	9.2	2.1	6.4
50	1	25.6	25.6	30.7	30.7
	2	15.1	15.1	21.2	21.2
	3	21.1	16.0	15.4	10.5
51	1	33.7	25.2	13.9	4.2
	2	9.6	23.7	32.5	21.5
	3	-1.9	9.0	-10.0	18.1
52	1	6.2	14.6	13.5	22.6
	2	12.6	12.6	15.1	5.9
	3	42.4	42.4	37.4	37.4
53	1	38.3	27.3	32.8	22.2
	2	39.9	29.3	35.2	25.0
	3	18.6	23.7	16.9	21.9
54	1	17.1	3.1	13.5	4.0
	2	-0.2	-12.6	4.9	0.5
	3	16.8	16.8	25.5	8.5
55	1	9.3	9.3	16.5	16.5
	2	30.5	30.5	36.9	36.9
	3	32.9	32.9	34.5	34.5
56	1	40.6	40.6	24.6	24.6
	2	18.0	18.0	21.4	21.4

Table 26. (Continued)

Farmer number:	Considered alternative number:	Expected annual per cent net return S_1	S_2	S_3	S_4
56	3	5.4	5.4	10.2	10.2
57	1	-0.8	11.0	-0.2	8.8
	2	10.7	15.5	7.6	3.1
	3	31.5	31.5	27.5	24.4
58	1	7.2	12.0	8.9	13.8
	2	28.4	28.4	32.9	32.9
	3	34.9	34.9	34.4	34.4
59	1	-0.9	3.3	8.9	0.3
	2	4.0	4.0	12.5	24.9
	3	6.2	10.8	15.4	18.0
	4	11.1	13.5	20.8	23.5
60	1	11.0	21.0	9.3	14.2
	2	8.5	18.5	6.9	11.8
	3	15.0	20.0	16.7	21.6
	4	14.3	19.4	16.1	21.0
61	1	21.1	1.7	14.1	2.0
	2	31.0	31.0	29.9	29.9
	3	33.2	33.2	33.8	33.8
	4	23.3	15.2	30.6	25.1
62	1	14.8	0.0	28.7	16.2
	2	6.5	-9.2	23.9	10.3
	3	30.3	14.7	21.3	6.1
	4	38.7	29.2	30.4	16.6
63	1	16.8	21.4	6.4	6.4
	2	41.5	41.5	30.1	30.1
	3	27.7	27.7	6.9	6.9
	4	12.7	12.7	17.9	17.9
64	1	7.0	7.0	12.5	12.5
	2	8.4	8.4	15.1	17.5
	3	22.5	11.0	27.1	13.0
	4	10.6	10.6	16.7	16.7
65	1	32.8	32.8	26.5	26.5
	2	35.7	35.7	29.5	29.5
	3	19.0	19.0	14.2	14.2
	4	20.4	20.4	15.7	15.7

Table 26. (Continued)

Farmer number:	Considered alternative number:	Expected annual per cent net return S_1	S_2	S_3	S_4
66	1	29.9	25.0	30.1	27.7
	2	38.7	30.8	36.7	31.7
	3	11.1	13.6	16.1	18.6
	4	3.8	6.1	8.5	10.9
67	1	22.6	12.6	26.1	21.2
	2	27.0	14.3	28.0	23.0
	3	30.5	17.2	27.3	24.7
	4	32.7	19.2	29.3	26.6
	5	-0.5	9.5	10.3	20.1
68	1	9.3	13.4	7.6	9.5
	2	7.5	7.5	0.8	0.8
	3	9.2	9.2	5.9	5.9
	4	2.9	2.9	4.6	4.6
	5	-6.9	-6.9	-9.2	-9.2
69	1	42.4	31.4	55.2	43.7
	2	3.6	12.9	4.4	18.3
	3	25.8	20.6	30.5	35.8
	4	11.9	11.9	15.1	15.1
	5	15.3	10.5	33.0	27.5
70	1	7.9	16.6	3.3	11.4
	2	15.1	25.1	21.0	25.8
	3	24.2	24.2	19.8	19.8
	4	19.0	19.0	13.8	13.8
	5	23.1	23.1	18.0	18.0
71	1	11.4	13.9	14.0	16.6
	2	16.1	16.1	20.9	20.9
	3	22.4	27.5	22.7	27.8
	4	26.6	26.6	21.1	21.1
	5	6.4	6.4	1.4	1.4
72	1	19.0	19.0	22.7	17.8
	2	13.5	8.7	19.7	14.7
	3	17.7	17.7	12.5	8.0
	4	21.6	16.7	17.1	12.4
	5	5.4	10.0	1.6	6.0
73	1	-5.8	2.2	0.5	13.3
	2	-1.4	3.2	11.2	16.2

Table 26. (Continued)

Farmer number:	Considered alternative number:	Expected annual per cent net return			
		S_1	S_2	S_3	S_4
73	3	16.4	16.4	19.6	19.6
	4	17.9	15.5	17.9	20.3
	5	23.6	18.7	26.0	18.8
	6	27.4	22.9	29.1	26.9
	7	19.3	16.7	26.5	23.9
74	1	6.9	6.9	20.0	20.0
	2	22.7	24.8	24.3	28.9
	3	35.7	46.1	34.0	44.3
	4	23.7	33.1	25.8	35.3
	5	38.0	48.8	41.1	48.8
	6	22.5	30.3	19.4	27.0
	7	12.5	12.5	17.0	17.0
75	1	14.5	7.2	22.7	10.4
	2	1.3	6.4	17.2	12.0
	3	12.6	10.2	12.8	5.1
	4	6.1	2.3	3.7	-1.3
	5	30.1	22.4	36.2	18.5
	6	30.2	21.1	28.4	16.7
	7	21.3	29.7	2.1	21.4
	8	13.6	25.0	4.8	15.8

XVIII. APPENDIX H: FARMER AND THEORETICAL SOLUTIONS TO THE PRACTICAL DECISION PROBLEMS

The farmers' solutions and those suggested by the Laplace, Wald and Savage criteria for the practical decision problems are listed in Table 27. In this table, blank spaces occur frequently in the solution columns. Such spaces indicate that the relevant alternative is not pertinent to the solution for the particular problem setting being considered.

For each problem setting, the farmer solutions show the proportions in which the farmer would have invested a given sum among each of his considered alternatives. The theoretical solutions were deduced from application of the relevant decision criteria to the payoff matrices of Appendix G. They show the proportions in which the farmer should have allocated his investment among his considered alternatives had he appraised the problems in terms of the theoretical criteria. Hence the theoretical solutions are normative.

In a number of cases, the Wald and Savage criteria dictate mixed strategies. These strategies were determined by the procedures for solving games outlined by Allen (3, pp. 511-516) and Heady (29).

Table 27. Solutions to the practical decision problems as given by the farmers, the Laplace equiprobability criterion, the Wald maximum criterion[a] and the Savage regret criterion[a]

Farmer number	Considered alternative number	Farmer solution			Laplace solution			Wald solution			Savage solution		
		G[b]	P[c]	E[d]	G	P	E	G	P	E	G	P	E
1	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

[a]With mixed strategies permitted.

[b]G denotes the problem setting with good weather certain.

[c]P denotes the problem setting with poor weather certain.

[d]E denotes the problem setting with either good or poor weather possible.

Table 27. (Continued)

Farmer number	Considered alternative number	Farmer solution G	Farmer solution P	Farmer solution E	Laplace solution G	Laplace solution P	Laplace solution E	Wald solution G	Wald solution P	Wald solution E	Savage solution G	Savage solution P	Savage solution E
11	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	1		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
14	1												
	2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
15	1				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	2	1.00	1.00	1.00									
16	1		1.00	0.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	2	1.00		0.50									
17	1	0.48	0.47	0.47	1.00			1.00		0.57	1.00		0.22
	2	0.52	0.53	0.53		1.00	1.00		1.00	0.43		1.00	0.78
18	1		1.00	1.00		1.00			1.00	1.00		1.00	0.35
	2	1.00			1.00		1.00	1.00			1.00		0.65
19	1	1.00		0.56	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	2		1.00	0.44									
20	1	0.48	0.48	0.48	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.51	0.52	0.52									
21	1		1.00					0.53	0.53	0.53	0.22	0.29	0.28
	2	1.00		1.00	1.00	1.00	1.00	0.47	0.47	0.47	0.78	0.71	0.72
22	1	1.00	1.00	1.00									

Table 27. (Continued)

Farmer number	Considered alternative number	Farmer solution G	P	E	Laplace solution G	P	E	Wald solution G	P	E	Savage solution G	P	E
22	2				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
23	1	0.53	0.52	0.52									
	2	0.47	0.48	0.47	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
24	1	0.55	0.54	0.55									
	2	0.45	0.46	0.45	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25	1	1.00			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	2			1.00									
26	1	1.00									0.43		0.43
	2				1.00	1.00	1.00	1.00	1.00	1.00	0.57	1.00	0.57
27	1	0.47	0.47	0.47		1.00		0.48	0.48	0.48	0.47	0.52	0.52
	2	0.53	0.53	0.53	1.00		1.00	0.52	0.52	0.52	0.53	0.48	0.48
28	1	0.17											
	2	0.83	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
29	1	0.46	0.47	0.47	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.54	0.53	0.53									
30	1	0.55	0.53	0.54							0.28	0.02	0.26
	2	0.45	0.47	0.46	1.00	1.00	1.00	1.00	1.00	1.00	0.72	0.98	0.74
31	1	0.44	0.43	0.44									
	2	0.56	0.57	0.56	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
32	1												
	2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 27. (Continued)

Farmer number	Considered alternative number	Farmer solution G	Farmer solution P	Farmer solution E	Laplace solution G	Laplace solution P	Laplace solution E	Wald solution G	Wald solution P	Wald solution E	Savage solution G	Savage solution P	Savage solution E
33	1	1.00	0.46	0.53				0.74			0.41		0.32
	2		0.54	0.47	1.00	1.00	1.00	0.26	1.00	1.00	0.59	1.00	0.68
34	1	1.00		1.00				1.00			0.37		0.12
	2		1.00		1.00	1.00	1.00		1.00	1.00	0.63	1.00	0.88
35	1	0.51	0.49	0.50		1.00		0.26			0.19	0.75	0.33
	2	0.49	0.51	0.50	1.00		1.00	0.74	1.00	1.00	0.81	0.24	0.67
36	1		1.00	0.49	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	2	1.00		0.51									
37	1	0.37	0.44	0.54									
	2	0.63	0.56	0.46	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
38	1	0.68	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.32											
39	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	2												
40	1	1.00		1.00							0.45		0.20
	2		1.00		1.00	1.00	1.00	1.00	1.00	1.00	0.55	1.00	0.80
41	1		0.53	0.46				0.50		0.50	0.41		0.41
	2	1.00	0.47	0.54	1.00	1.00	1.00	0.50	1.00	0.50	0.59	1.00	0.59
42	1	0.43											
	2	0.57	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
43	1	0.47	0.49	0.48								0.12	0.09

Table 27. (Continued)

Farmer number	Considered alternative number	Farmer solution G	P	E	Laplace solution G	P	E	Wald solution G	P	E	Savage solution G	P	E
43	2	0.53	0.51	0.52	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.87	0.91
44	1	0.70	0.70	0.70									
	2	0.30	0.30	0.30	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
45	1	1.00											
	2												
	3		1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
46	1	0.58	0.55	0.56				0.09			0.25		0.25
	2	0.42	0.45	0.44	1.00	1.00	1.00	0.91	1.00	1.00	0.75	1.00	0.75
	3												
47	1	0.56	0.57	0.57	1.00	1.00	1.00	1.00			1.00	0.57	0.71
	2	0.22	0.22	0.22									
	3	0.22	0.21	0.21					1.00	1.00		0.43	0.29
48	1	0.23	0.41	0.40									
	2	0.36	0.59	0.60	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	3	0.41											
49	1	0.22											
	2	0.78		0.51									
	3		1.00	0.49	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50	1	1.00		0.67	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	2												
	3		1.00	0.33									
51	1	1.00		0.52	1.00			1.00		0.29	1.00		0.56
	2			0.48		1.00	1.00		1.00	0.71		1.00	0.44

Table 27. (Continued)

Farmer number	Considered alternative number	Farmer solution G	Farmer solution P	Farmer solution E	Laplace solution G	Laplace solution P	Laplace solution E	Wald solution G	Wald solution P	Wald solution E	Savage solution G	Savage solution P	Savage solution E
51	3		1.00										
52	1												
	2	0.39											
	3	0.61	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
53	1	0.57											
	2		0.57	0.56	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	3	0.43	0.43	0.44									
54	1										0.02		0.02
	2	1.00											
	3		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	1.00	0.98
55	1		0.32										
	2	0.52	0.35	0.51		1.00	1.00		1.00			1.00	0.50
	3	0.48	0.33	0.48	1.00			1.00		1.00	1.00		0.50
56	1	0.53	0.56	0.55	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.47	0.44	0.45									
	3												
57	1												
	2												
	3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
58	1	0.33	0.26	0.27									
	2	0.37	0.41	0.40									
	3	0.30	0.33	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
59	1	0.25	0.26	0.26									

Table 27. (Continued)

Farmer number	Considered alternative number	Farmer solution			Laplace solution			Wald solution			Savage solution		
		G	P	E	G	P	E	G	P	E	G	P	E
59	2	0.26	0.25	0.25								0.14	0.13
	3	0.25	0.25	0.25									
	4	0.24	0.24	0.24	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.86	0.87
60	1	0.52	0.51	0.52							0.18		0.12
	2												
	3	0.48	0.49	0.48	1.00	1.00	1.00	1.00	1.00	1.00	0.82	1.00	0.88
	4												
61	1	0.22	0.40	0.18									
	2	0.32	0.26	0.37									
	3	0.31	0.24	0.35	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	4	0.14	0.10	0.10									
62	1												
	2	0.20		0.13									
	3												
	4	0.80	1.00	0.87	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
63	1	0.30											
	2	0.40	0.36	0.57	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	3	0.30	0.26	0.42									
	4		0.38										
64	1	0.24	0.24	0.24									
	2	0.29	0.29	0.29					0.86			0.27	0.24
	3	0.29	0.30	0.29	1.00	1.00	1.00	1.00	0.14	1.00	1.00	0.73	0.76
	4	0.18	0.17	0.18									
65	1	0.33	0.33	0.33									
	2	0.35	0.35	0.35	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 27. (Continued)

Farmer number	Considered alternative number	Farmer solution G	P	E	Laplace solution G	P	E	Wald solution G	P	E	Savage solution G	P	E
65	3	0.16	0.16	0.16									
	4	0.16	0.16	0.16									
66	1	0.30	0.18	0.24									
	2	0.22	0.34	0.28	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	3	0.18	0.28	0.23									
	4	0.30	0.20	0.25									
67	1												
	2												
	3	0.45	0.45	0.45									
	4	0.55	0.55	0.55	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	5												
68	1	0.29	0.29	0.29	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.27	0.27	0.27									
	3												
	4	0.12	0.12	0.12									
	5	0.32	0.32	0.32									
69	1	0.51	0.52	0.51	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	2												
	3	0.27	0.27	0.28									
	4												
	5	0.22	0.21	0.21									
70	1		0.27	0.39									
	2	0.13	0.12	0.17		1.00			1.00	0.29	0.09	1.00	0.40
	3	0.33	0.30	0.44	1.00		1.00	1.00		0.71	0.91		0.60
	4	0.54											
	5		0.31										

Table 27. (Continued)

Farmer number	Considered alternative number	Farmer solution			Laplace solution			Wald solution			Savage solution		
		G	P	E	G	P	E	G	P	E	G	P	E
71	1	0.23		0.15									
	2	0.26	0.33	0.32									
	3	0.19	0.25	0.12		1.00	1.00		1.00	0.95	0.18	1.00	0.61
	4	0.20	0.26	0.25	1.00			1.00		0.05	0.82		0.39
	5	0.12	0.16	0.16									
72	1		0.41		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	2	0.46											
	3	0.18		0.27									
	4		0.59	0.26							0.53		0.32
	5	0.36		0.47									
73	1												
	2												
	3												
	4												
	5	0.56		0.52									
	6	0.44	1.00	0.48	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	7												
74	1	0.31	0.30	0.30									
	2	0.36	0.36	0.36									
	3	0.17	0.18	0.18									
	4	0.16	0.16	0.16									
	5				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	6												
	7												
75	1												
	2												
	3												

Table 27. (Continued)

Farmer number	Considered alternative number	Farmer solution			Laplace solution			Wald solution			Savage solution		
		G	P	E	G	P	E	G	P	E	G	P	E
75	4	1.00	1.00	1.00									
	5				1.00	1.00	1.00	0.52	0.52	0.52	0.55	0.92	0.82
	6												
	7							0.48	0.48	0.48	0.45	0.08	0.18
	8												

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